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AIRWORTHINESS AND FLIGHT CHARACTERISTICS
CH-47C HELICOPTER (CHINOOK)

STABILITY AND CONTROL

FINAL REPORT

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US ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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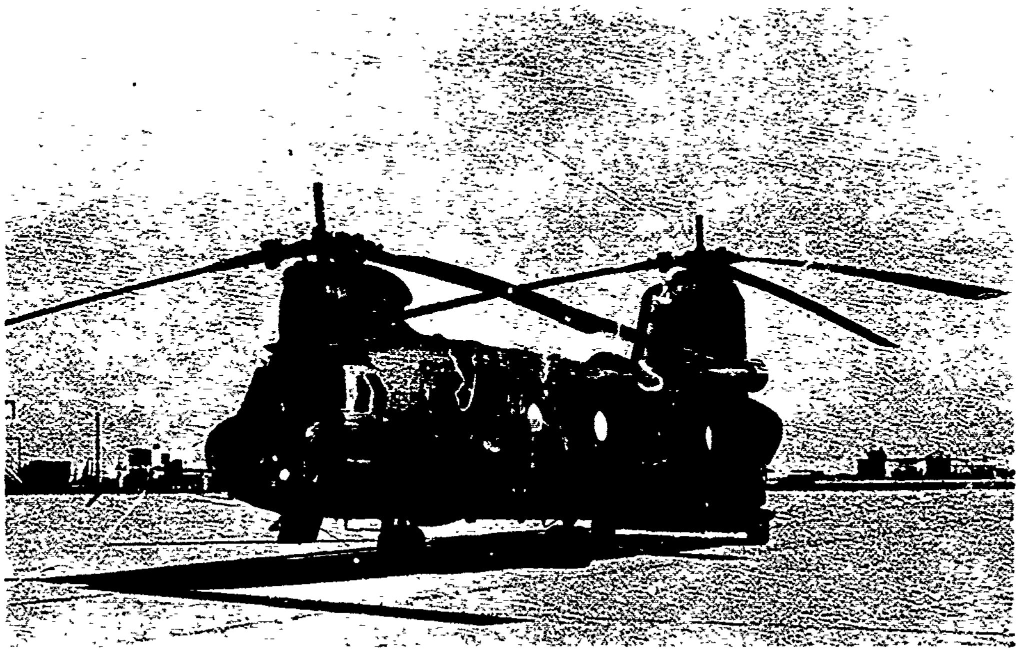
ABSTRACT

The second phase of the CH-47C airworthiness and flight characteristics (A&FC) test program consisted of the stability and control test of the production helicopter. Tests were conducted in California at Edwards Air Force Base during the period 8 March to 15 July 1971. The CH-47C was evaluated to determine compliance with the military specification, MIL-H-8501A, with deviations as defined in the detail specification. The helicopter was also evaluated with respect to its mission as a transport helicopter. The CH-47C stability and control characteristics are acceptable for the transport helicopter mission. Correction of the deficiency of excessive torque split with T55-L-11A engines is mandatory prior to operational use. Twelve shortcomings were found during this test. Static longitudinal stability characteristics (with the pitch stability augmentation system (PSA) OFF) failed to meet requirements of the detail specification. The dynamic stability characteristics with the PSA system OFF failed to meet the requirements of the military specification, and the hover directional control power failed to meet the requirements of the military specification. An investigation is recommended to determine the cause of torque splits with the T55-L-11A engines. Additional recommendations are to prohibit intentional flight in instrument conditions with one stability augmentation system (SAS) inoperative and to place a "WARNING" in the operator's manual stating that during instrument flight with only one SAS operating, failure of that SAS could result in a loss of aircraft control. The CH-47C should also be equipped with a structural load indicator.



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INTRODUCTION

BACKGROUND

1. Experience with the CH-47A/B helicopter in Vietnam has verified the importance of improving payload and speed capability at high density altitudes to increase combat effectiveness of the aircraft.

2. The product improvement program (ref 1, app I) defined a two-step program to incorporate performance, stability, and vibration-level improvements in production CH-47 helicopters. The aircraft configured for step-one modifications has been identified as configuration IA and designated as the CH-47B. The second step in the product improvement program provides for increased engine horsepower and necessary modification to accomodate the higher power for a further increase in payload capability. The aircraft configured for step-two modifications has been identified as configuration II and designated as the CH-47C.

3. The test directive (ref 2, app I) issued by the US Army Test and Evaluation Command (TECOM) directed the US Army Aviation Systems Test Activity (USAASTA) to participate in the product improvement program. This participation included the conduct of tests on the production configuration CH-47C to acquire detailed performance and stability and control information. The revised test directive (ref 3) issued by the US Army Aviation Systems Command (AVSCOM) provided additional guidance and forwarded changes which were incorporated in the test plan (ref 4).

TEST OBJECTIVE

4. The objective of the airworthiness and flight characteristics (A&FC) stability and control test was to acquire stability and control data on a production CH-47C with respect to the transport helicopter mission. Tests were conducted to determine the degree to which the helicopter conforms to:

   a. Military specification, MIL-H-8501A (ref 5, app I).

   b. Detail specification for the model CH-47C helicopter (ref 6, app I).

DESCRIPTION

5. The test helicopter was a production CH-47C, serial number (S/N) 68-15859 (production tab number B-571), manufactured by the Vertol Division of The Boeing Company (Boeing-Vertol). It is a twin-engine, turbine-powered, tandem-rotor helicopter designed to provide air transportation for cargo, troops, and weapons during day or night visual-flight-rule (VFR) and instrument-flight-rule (IFR)

conditions. The helicopter is powered by two Lycoming T55-L-11A turboshaft engines mounted in separate nacelles on the aft portion of the fuselage. The engines drive two three-bladed rotors in tandem through a combining transmission, drive shafting, and reduction transmissions. A gas turbine auxiliary power unit hydraulically drives the aft transmission accessory gearbox to provide hydraulic and electrical power for engine starting and other ground operations when the rotors are not turning. Two pods, containing three fuel tanks each, are located on either side of the fuselage. The helicopter is equipped with four nonretractable landing gear. An entrance door is located at the forward right side of the cabin fuselage section. A hydraulically powered loading ramp is located at the rear of the cargo compartment. Side-by-side seating arrangement is provided for the pilots.

6. All tests were conducted with the cargo mirror removed and engine inlet screens installed. Engineering Change Proposal (ECP) 660, *Armor Kit*, was installed. All openings were closed, except for the lower rescue door, which was removed. The aircraft characteristics of the CH-47C and the flight control system description are presented as appendixes II and III, respectively.

7. The test helicopter was powered by two uncalibrated T55-L-11A turboshaft engines rated at 3,750 shaft horsepower (shp) each. The engines were modified from production T55-L-11 engines to T55-L-11A engines by incorporation of the following changes:

a. Face seal and jet pump power package.

b. Flexible combustor liner brackets.

c. Combustor liner, part number 2-131-110-17.

d. Improved oil tube clamps and "O" rings.

e. Power turbine structural fix.

f. Fireshield brackets.

g. Fuel control spline wear fix.

h. Hard-faced and shot-peened blades in the fourth stage power turbine.

i. Revised inlet guide vane schedule.

SCOPE OF TEST

8. During the test program, 42 flights were conducted for a total of 52 hours, of which 33.5 were productive. Testing was conducted at Edwards Air Force Base, California (2,302-foot elevation), from 8 March to 15 July 1971. Maintenance and instrumentation support was provided by USAASTA personnel.

9. The CH-47C was evaluated with respect to its mission as a transport helicopter as defined in the detail specification (ref 6, app I). To preclude duplication of previous tests conducted on prototype CH-47C helicopters, the tests were conducted at conditions determined to be most critical during the CH-47C Army Preliminary Evaluations (refs 7 and 8). These conditions were generally heavy gross weights and aft center of gravity (cg) with internal loading. Also, tests were conducted with a high-density (10,000 pounds of concrete) sling-load. The revised test plan for the stability and control portion of Project No. 66-29 (ref 9) was approved by AVSCOM. Test conditions were nominally 33,000-pound and 46,000-pound gross weights at a maximum allowable aft cg. Density altitude varied from approximately 3,700 to 8,000 feet. Flight from 30 knots true airspeed (KTAS) rearward to the limit forward airspeed was evaluated. Left and right sideward flight to 35 KTAS was also evaluated. The operating limitations in the operator's manual (ref 10) were observed. Qualitative ratings of the handling qualities were based on the Handling Qualities Rating Scale (HQRS) (app IV).

METHODS OF TEST

10. The methods of test used are established engineering flight test techniques and are briefly described in the Results and Discussion section of this report.

11. Data were recorded on a photopanel and oscillograph. A detailed list of test helicopter instrumentation parameters is included in appendix V.

CHRONOLOGY

12. The chronology of the CH-47C A&FC stability and control test program is as follows:

Test request received	29 April 1969
Aircraft received	12 May 1969
Aircraft used to conduct other tests	13 May 1969 through 7 March 1971
Stability and control tests started	8 March 1971
Aircraft down for first stage compressor modification	5 April 1971
Aircraft in flying status after engine modifications	30 April 1971
Stability and control tests completed	15 July 1971

RESULTS AND DISCUSSION

GENERAL

13. The CH-47C stability and control characteristics are acceptable for the transport helicopter mission. Correction of the deficiency of excessive torque split with T55-L-11A engines is mandatory prior to operational use. Twelve shortcomings were found during the test. Static longitudinal stability characteristics with the pitch stability augmentation system (PSA) OFF failed to meet requirements of the detail specification. The dynamic stability characteristics with the PSA system OFF and hover directional control power failed to meet the requirements of the military specification. An investigation is recommended to determine the cause of torque splits with the T55-L-11A engines. Additional recommendations are to prohibit intentional flight in instrument conditions with one stability augmentation system (SAS) inoperative and to place a "WARNING" in the operator's manual stating that during instrument flight with only one SAS operating, failure of that SAS could result in a loss of aircraft control. The CH-47C should be equipped with a structural load indicator.

STABILITY AND CONTROL

Trimmability

14. Within the scope of these tests, the longitudinal, lateral, and directional control forces could be trimmed to zero using the control centering switch. A very precise longitudinal and lateral control centering was provided, and the directional control centering was positive. No undesirable stick "jump" was apparent when using the centering device release switch. Small trim changes in one axis of control required retrimming of all three axes. Precise trimming in all axes was particularly time consuming during instrument flight and reduced the pilot's ability to accomplish other tasks (HQRS 4). The trimmability characteristics of the CH-47C met the requirements of the military specification. However, correction of the poor trimmability characteristics is desirable for improved operation and mission capabilities.

15. With the PSA system in the NORMAL mode, uncommanded pitch attitude changes occurred when the centering device release switch was activated following longitudinal control displacement. When a new airspeed slower than trim was selected, the uncommanded pitch change was nose up; and when the new airspeed selected was faster than trim, the pitch change was nose down. This shortcoming was also experienced during the Army Preliminary Evaluation (APE) III test. The APE III test report (ref 8, app I) stated that the magnitude of pitch attitude change was equivalent to approximately 2.5 inches of stick travel when the airspeed change was more than 30 knots prior to activation of the centering device release switch. Smaller airspeed changes produced proportionately smaller pitch attitude

changes. The pitch attitude change could be compensated for by the pilot but increased the workload during maneuvering tasks such as takeoffs, landings, and banked turns (HQRS 4). Pilot effort during sling load operation and under instrument conditions was greater (HQRS 5). To preclude uncommanded attitude changes, the centering device release button must be depressed prior to changing airspeed. This technique resulted in deactivation of the PSA system during the time the button was depressed. However, the resultant loss of the PSA system was less troublesome than uncommanded pitch attitude changes. Uncommanded pitch attitude changes associated with retrimming operations occurred only when the PSA system was operating in the NORMAL mode. The following "NOTE" should be placed in the operator's manual:

NOTE

> To preclude the occurrence of uncommanded pitch attitude changes when operating with the pitch stability augmentation system in the NORMAL mode, depress the centering device release button prior to initiating an attitude or airspeed trim change and release the button only after achieving the new flight condition.

Correction of the uncommanded pitch attitude change associated with retrimming operations when the PSA system is in the NORMAL mode is desirable for improved operation and mission capabilities.

Trim Control Position Characteristics

16. Trim control position characteristics were investigated by trimming the helicopter in coordinated steady-heading level flight, and in sideward and rearward flight. Airspeed was incrementally increased while the thrust control rod was adjusted to maintain altitude, and control positions were recorded for each stabilized condition. A pacer vehicle with a calibrated fifth wheel was used to determine airspeed during sideward, rearward, and slow-speed forward flight.

17. Trim control positions were evaluated in level flight at gross weights of 46,000 and 33,000 pounds with an aft cg. The results are presented as figures 1 through 3, appendix VI, for a density altitude of approximately 5,000 feet and in figure 4, for a density altitude of approximately 8,000 feet. For the conditions tested, lateral and directional control position changes with airspeed are minimal and pitch attitude changes were small. Figure 1 shows that longitudinal trim control positions are identical with the PSA system OFF or operating in the NORMAL or the AUTO mode. At a 5,000-foot density altitude, the longitudinal trim control position gradient was neutral to slightly negative (where negative is defined as aft control displacement with increasing forward speed) between 50 and 150 knots calibrated airspeed (KCAS). Moderate pilot effort was required to stabilize at an airspeed between 50 and 80 KCAS. Slightly less pilot effort was required to stabilize at airspeeds above 80 KCAS. This effort increased during flight in simulated instrument conditions (HQRS 4). Trim control position characteristics

with a high-density external sling load were essentially the same as without the sling load (fig. 3). The longitudinal trim control position gradient at a 46,000-pound gross weight, an aft cg, and a density altitude of 8,255 feet is shown in figure 4. The gradient was slightly positive from 55 to 75 KCAS, but considerable pilot effort was required to maintain a precise airspeed (HQRS 5). When operating at maximum gross weight and altitude, limit forward airspeed can be easily exceeded, unless considerable pilot effort is devoted to attitude and airspeed control. Reduction of the pilot effort required to maintain trim airspeed in the CH-47C helicopter is desirable for improved operation and mission capabilities.

18. Sideward flight was evaluated by translating left and right in 5-knot increments up to 37 KTAS. Trim control positions are presented in figure 5, appendix VI, for a gross weight of 46,370 pounds and a cg at fuselage station (FS) 335.2. Longitudinal and directional trim control position changes from hover to 37 KTAS sideward were minimal. The lateral trim control position gradient was positive (increased control displacement in direction of flight) from hover to approximately 20 KTAS sideward. Roll attitude did not exceed 3 degrees during sideward flight. Minimal pilot effort was required to transition and stabilize in sideward flight (HQRS 2). Similar sideward flight characteristics were reported at lighter gross weights in APE II (ref 7, app I). The sideward flight characteristics of the CH-47C met the requirements of paragraph 3.3.2 of the military specification and are satisfactory for Army use.

19. Rearward and slow-speed forward flight were evaluated by translating in 5-knot increments up to 30 KTAS rearward and 40 KTAS forward. The test results are presented as figure 6, appendix VI, for a gross weight of 45,390 pounds and a cg at FS 335.6. In trimmed rearward flight from hover to 30 KTAS, the lateral and directional trim control position changes were small. Thrust control rod (collective) position changes and pitch attitude changes were also minimal. In trimmed rearward flight, the longitudinal control position gradient was neutral to slightly positive from hover to 10 KTAS and became increasingly positive to 30 KTAS. Minimal pilot effort was required to stabilize on an airspeed in rearward flight (HQRS 2). In trimmed slow-speed forward flight from hover to 15 KTAS, the longitudinal control position gradient was neutral to slightly positive and became increasingly positive to 40 KTAS. Slow-speed forward flight required minimal pilot effort (HQRS 2). Similar results are presented in APE II for lighter gross weights. The rearward and slow-speed forward flight characteristics met the requirements of paragraph 3.2.1 of the military specification and are satisfactory for Army use.

20. Pitch attitude changes resulting from thrust control rod changes were observed in transition from level flight at 80 knots indicated airspeed (KIAS) to maximum power climb and minimum power descent. The average gross weight was 33,000 pounds with the cg at FS 338 at a density altitude of approximately 5,000 feet. With the PSA system operating in the AUTO or NORMAL mode, raising the thrust control rod resulted in a transient nose-down pitching moment, and lowering the thrust control rod resulted in a transient nose-up pitching moment. With controls fixed, the attitude retention feature of the PSA system corrected the pitch attitude change, but with a resultant change in airspeed. Raising the

thrust control rod to maximum power at a rate of 0.6 inch per second (in./sec) resulted in an increased airspeed of approximately 5 KIAS in a climb. Rapidly raising the control (1.25 in./sec) resulted in a 10-KIAS increase in airspeed. Lowering the thrust control rapidly resulted in a descent and less than a 3-KIAS reduction. Minimal pilot effort was required to maintain a precise indicated airspeed during thrust control rod changes with the PSA system operating in the AUTO or NORMAL mode (HQRS 3). With the PSA system OFF and controls fixed, the pitching moments developed from thrust control rod changes were in the same direction; but unless pilot corrective action was taken, the helicopter continued to pitch with a subsequent gain or loss of airspeed. The magnitude of the pitching rate increased with the magnitude of thrust control rod application. The longitudinal control trim position changes, from maximum power climb to minimum power descent (0.77 in.), met the requirements of the military specification. However, moderate pilot compensation was required to maintain a precise indicated airspeed during thrust control rod changes with the PSA system OFF (HQRS 4). Similar attitude changes were observed at a gross weight of 46,000 pounds. As an interim measure, thrust control rod changes should be made slowly to minimize pilot effort to maintain airspeed during power changes. Correction of the undesirable pitch attitude changes resulting from thrust control rod changes is desirable for improved operation and mission capabilities.

Static Longitudinal Stability

21. Static longitudinal stability characteristics were investigated by trimming the helicopter in steady-heading level flight, maximum power climb, and autorotation. Level flight characteristics were also investigated with a high-density (10,000-pound) external sling load. Airspeed was incrementally increased and decreased from the trim airspeed with collective fixed, and data were recorded for each stabilized condition.

22. Static longitudinal stability characteristics, as indicated by the variation of longitudinal control position with airspeed, with the PSA system operating in the NORMAL mode, are presented as figures 7 through 10, appendix VI. The gradient of the longitudinal control position with respect to airspeed indicates that the aircraft stability was positive within 12 knots of the trim airspeed for all conditions tested. At speeds in excess of 12 knots from the trim speed, the gradient shows that the stability tended to become neutral to negative as the authority of the differential collective pitch (DCP) actuator was exceeded. Pitch attitude control of the helicopter with the PSA system operating in the NORMAL mode was good. The gradients of lateral and directional control positions versus airspeed about trim were essentially neutral and presented no problem in control of the helicopter (HQRS 2). The requirements of the detail specification were met within 12 knots of the trim airspeed with the PSA system operating in the NORMAL mode. The static longitudinal stability characteristics with the PSA system in the AUTO mode were the same as in the NORMAL mode, so long as the longitudinal control was not displaced from the original trim position. This stability was apparent in the helicopter's tendency to return to the trim pitch attitude and airspeed following an external disturbance. However, when the longitudinal control was displaced from

the original trim position, the characteristics of control position with respect to airspeed with the PSA system operating in the AUTO mode were similar to the characteristics with the PSA system OFF (because of the DCP actuator retrimming to a new airspeed). The static longitudinal stability characteristics of the CH-47C with the PSA system ON are satisfactory for Army use.

23. Static longitudinal stability characteristics with the PSA system OFF, as indicated by the variation of longitudinal control position with airspeed, are presented as figures 9 through 13, appendix VI. With the PSA system OFF, the gradient of longitudinal control position with respect to airspeed was neutral to negative for all conditions tested. These same static stability characteristics also existed at any time the PSA system was ON, and in the AUTO mode with the longitudinal control displaced from the original trim position (fig. 14). With the PSA system OFF, minimal pilot compensation was required for attitude and airspeed control in VFR conditions (HQRS 3). During simulated IFR conditions, a moderate degree of pilot effort was required (HQRS 4). With a high-density sling load, pilot effort was increased to moderate in VFR conditions (HQRS 4), and considerable effort was required in simulated IFR conditions (HQRS 5). With the PSA system OFF, the requirements of deviations 5 and 11 of the detail specification were not met, in that the gradient of the longitudinal control positions with respect to airspeed was not positive for all conditions tested. Correction of the poor static longitudinal stability characteristics with the PSA system OFF is desirable for improved operation and mission capabilities.

Static Lateral-Directional Stability

24. Static lateral-directional stability characteristics were evaluated during level flight, climb, and autorotation. Lateral-directional characteristics were also evaluated in level flight with a high-density (10,000-pound) external sling load. These tests were conducted by first trimming in ball-centered flight and then increasing the sideslip angles left and right in approximate 5-degree increments while maintaining a steady heading. Data were recorded for each stabilized condition.

25. Level flight lateral-directional stability characteristics are presented as figures 15 through 18, appendix VI. As evidenced by the positive and essentially linear directional control position gradients, the aircraft exhibited positive directional stability. The directional control position gradients were essentially identical for all trim speeds. Dihedral effect, as indicated by the variation of lateral control displacement with sideslip, was positive, essentially linear, and nearly identical for all trim speeds. Directional control position gradients and dihedral effect were invariant with the PSA system selection. Longitudinal trim changes during steady-heading sideslips at an approximate 83-KCAS trim speed were characterized by an increasing requirement for aft longitudinal cyclic control as sideslip was increased left and right. The requirement for aft cyclic control was greater with the PSA system in the NORMAL mode, with a maximum displacement of approximately 1.5 inches at 18 degrees of right sideslip. At an approximate 103-KCAS trim speed, longitudinal cyclic variation with sideslip was essentially neutral, with a maximum change of approximately 0.5 inch at 8 degrees of right

sideslip with the PSA system in the NORMAL mode. Within the scope of this test, longitudinal cyclic control movement with sideslip was not objectionable and will not degrade mission effectiveness. Side-force characteristics were evaluated by recording the variation of bank angle with sideslip. Between ± 10 degrees of sideslip, the bank angle was approximately +2 degrees for both trim speeds, and varied to a maximum of 5 degrees of left bank while flying at 84 KCAS and 30 degrees of left sideslip. The weak side-force characteristics as indicated by bank angle will not degrade the transport helicopter mission. Within the scope of these tests, the maximum sideslip angles attained met the requirements of the detail specification. The static lateral-directional stability characteristics of the CH-47C in level flight are satisfactory for Army use.

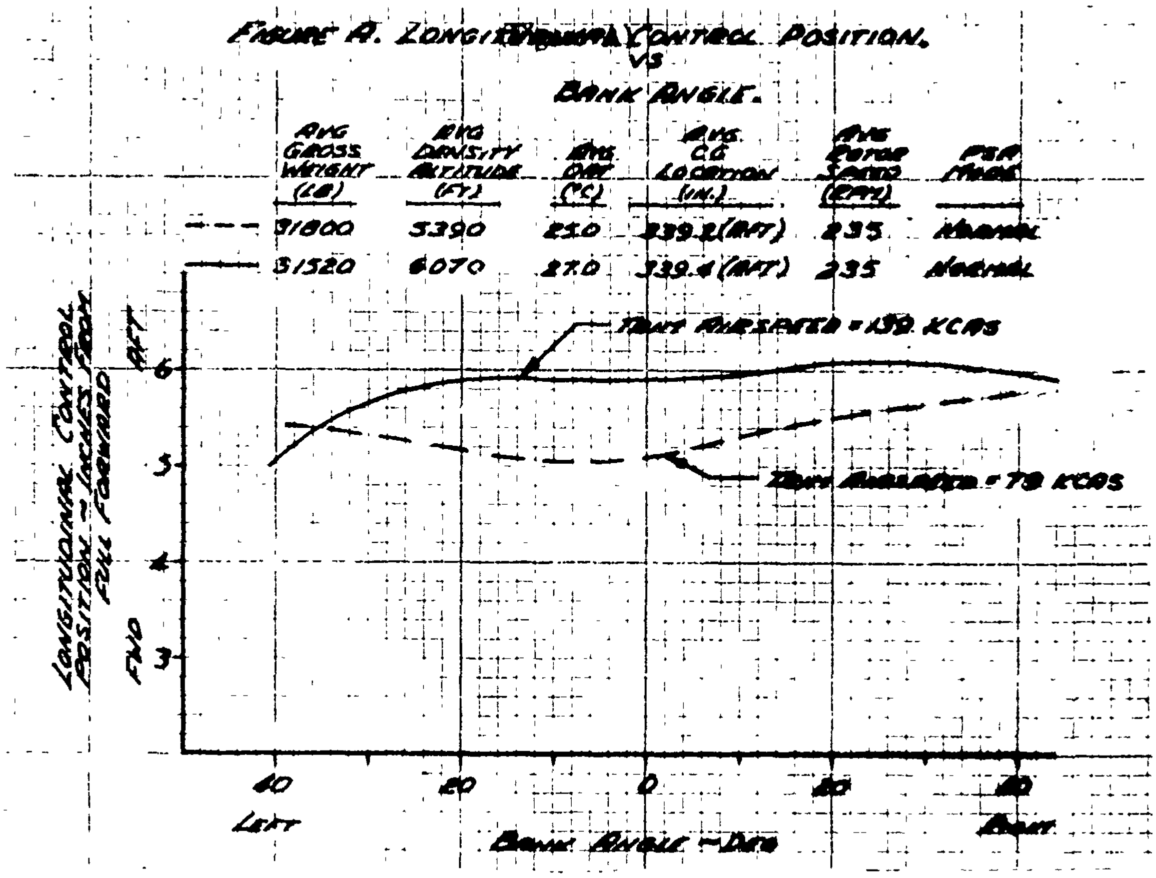
26. Static lateral-directional stability characteristics in climbs and autorotations are presented as figure 19, appendix VI. The stability characteristics in climbs and autorotations were generally similar to those exhibited during level flight testing and met the requirements of the detail specification. The static lateral-directional stability characteristics of the CH-47C during climbs and autorotations are satisfactory for Army use.

27. Static lateral-directional stability characteristics in level flight while carrying a 10,000-pound high-density sling load are presented as figures 20 and 21, appendix VI. The results of these tests were also similar to those exhibited during level flight, climb, and autorotation without the sling load. Qualitatively, it was determined that the pilot workload in stabilizing at test points was greatly increased while flying with the PSA system in the AUTO mode. During these tests, small longitudinal oscillations of the external load caused pitch changes requiring constant longitudinal cyclic compensation by the pilot. These small cyclic movements were of sufficient magnitude to intermittently deactivate the PSA system in the AUTO mode, thereby causing increased pilot effort to fly a constant airspeed (HQRS 5). The static lateral-directional stability characteristics of the CH-47C while carrying an external load met the requirements of the detail specification and are satisfactory for Army use.

Maneuvering Flight Characteristics

28. Maneuvering flight characteristics of the CH-47C were evaluated in left and right banked turns to the limit bank angle. The turns were accomplished at constant power and constant airspeeds of 79 and 139 KCAS. The average gross weight was 31,650 pounds with a cg at FS 339.3. The longitudinal control position variation with bank angle is presented as figure A. At 79 KCAS, the gradient of longitudinal control position versus bank angle was positive, in that aft longitudinal control was required with increased bank angle. Minimal pilot compensation was required for airspeed control and was essentially the same in left and right turns (HQRS 3). At 139 KCAS, the gradient of longitudinal control position versus bank angle for right turns was essentially neutral up to 30 degrees of bank and then became negative. In left turns, the gradient was essentially neutral up to 15 degrees of bank and then became increasingly negative with increased bank angle. In right turns, moderate pilot compensation was required to maintain airspeed at banks

in excess of 35 degrees (HQRS 4) and in left turns, considerable pilot effort was required to maintain airspeed above bank angles of 25 degrees (HQRS 5). Improvement of the poor high-speed maneuvering characteristics is desired for improved operation and mission capabilities.



29. During APE II (ref 7, app I), aft rotor stall was reported in maneuvering flight at bank angles greater than 30 degrees. An evaluation was made to determine if aft rotor stall could occur within the allowable flight envelope. The evaluation was made in constant altitude turns (right and left) at 46,000- and 33,000-pound gross weights with a cg at the aft limit. Longitudinal, lateral, and directional control pulses were introduced with the pulser box (para 31) through the number-one SAS in an attempt to excite the aft rotor stall. Pulses were introduced in both directions in each control axis equal to control displacements of approximately ±0.9 inch, longitudinally; ±0.5 inch, laterally; and ±0.8 inch, directionally. The control displacement was held for 0.5 to 1.0 second and then returned to the original position. The maximum bank angle for each gross weight (45 degrees at 33,000 pounds and 30 degrees at 46,000 pounds) and the maximum level flight airspeed were determined to be the most critical conditions. During these tests, aft rotor blade stall was not observed. Adherence to the published flight envelope should preclude any occurrence of aft rotor stall.

30. The maneuvering flight characteristics were qualitatively determined to be the same as those reported in paragraph 41 of APE III and APE IV (ref 8, app I) with the PSA system operating in the AUTO mode. During constant-altitude or constant-power turns, the pilot was continually required to move the longitudinal control in and out of the detent position to maintain attitude and airspeed. Correction of the poor maneuvering flight characteristics with the PSA system operating in the AUTO mode is desirable for improved operation and mission capabilities.

Dynamic Stability

31. Dynamic stability characteristics were investigated in steady-heading level flight, climb, descent, autorotation, hover, sideward, and rearward flight. Control pulses of approximately 1-inch amplitude and 0.5-second duration were introduced into all three axes to simulate gust upsets by using a mechanical fixture. A SAS pulser box was also used to input disturbances through the number-one SAS. The SAS inputs were 100 percent of the applicable extensible link authority for each axis and equal to control displacements of approximately ±0.9 inch, longitudinally; ±0.5 inch, laterally; and ±0.8 inch, directionally. A calibrated pace vehicle was used to determine airspeed during sideward and rearward flight.

32. During all flight conditions while operating with the PSA system in the NORMAL mode, the aircraft longitudinal response to mechanical or pulser box inputs was oscillatory, convergent, and well damped. During flight with the PSA system operating in the AUTO mode, the aircraft response to mechanical or pulser box inputs was also oscillatory, convergent, and well damped. The aircraft pitch response to simulated gust inputs during forward flight with the PSA system OFF was aperiodically divergent in the direction of the input (fig. 22, app VI). In hover, with the PSA system OFF, the response of the aircraft was characterized by a much slower divergence in the direction of the input. During the PSA system OFF operation, the CH-47C failed to meet the requirements of paragraphs 3.2.11 and 3.6.1.2 of MIL-H-8501A, in that the resultant pitch response to simulated gust inputs was aperiodically divergent.

33. The lateral and directional attitude responses of the test aircraft to mechanical or pulser box inputs were essentially deadbeat, and well damped within 4 seconds (figs. 23 through 26, app VI). The dynamic characteristics in the roll and yaw axes afforded the pilot good control feel and contributed to precise maneuverability (HQRS 2).

34. The short-term dynamic response was evaluated by observing the time history of pitch attitude, angle of attack, and normal acceleration subsequent to a longitudinal disturbance. The disturbances were introduced by approximately 1-second doublets and/or 1-second pulses. The short-term response with the PSA system OFF, or while operating in the NORMAL or AUTO modes, was qualitatively observed to be essentially deadbeat, and afforded good control response and precise maneuverability.

35. The long-term dynamic response was evaluated qualitatively and quantitatively at the following conditions: a trim speed of 110 KIAS at a gross weight of approximately 34,000 pounds, and a trim speed of 104 KCAS at a gross weight of 45,000 pounds. Comparative evaluations were made with the PSA system OFF and operating in the NORMAL or AUTO modes. The tests were conducted by returning the longitudinal control to the initial trim position following an incremental increase or decrease of 10 KIAS, or by using pulser box inputs. With the PSA system operating in the NORMAL mode, the response of the aircraft was essentially deadbeat with no detectable overshoot. In the AUTO mode, the long-term dynamic response following a pulser box input was essentially identical to that observed while operating with the PSA system in the NORMAL mode, so long as the longitudinal control remained within the ±1/8-inch detent. Because of the AUTO mode characteristics, off-trim holding is not a valid technique for evaluating the long-term response, in that the aircraft merely remains trimmed in level flight at the newly commanded trim speed. The PSA system (AUTO and NORMAL mode) provided a long-term pitch attitude response following pulse inputs that returns the aircraft to trim, with no overshoot, in approximately 6 seconds during level flight and within 3 seconds during hover (figs. 27 through 30, app VI). While operating with the PSA system in the NORMAL mode, the essentially deadbeat long-term response following off-trim holding will augment the IFR capabilities of the CH-47C.

36. The dynamic stability characteristics (PSA system ON) met the requirements of the military specification. Within the scope of this test, the dynamic stability characteristics of the CH-47C are satisfactory for Army use.

Controllability

37. Controllability characteristics were measured about all axes during level flight, climb, autorotation, low-speed flight, and hover. The average gross weight was 46,000 pounds at an average cg at FS 335. Level flight and hover characteristics were also evaluated with a high-density, 10,000-pound external sling load. These tests were conducted by inducing control step inputs using a SAS pulser box operating through the number-one SAS. Additional control step inputs and pulses were induced using the pilot cyclic and pedal controls by restraining control movements with adjustable mechanical fixtures. For purposes of comparison, the tests were conducted with the PSA system OFF and operating in the NORMAL or AUTO mode.

38. A 30-foot in-ground-effect (IGE) hover control power was evaluated against the requirement of the military specification, with consideration given to mission suitability. The results of these tests and applicable specification requirements are summarized in table 1 together with comparative data from APE II (ref 7, app I).

Table 1. Hover Control Power In-Ground-Effect at a 30-Foot Wheel Height.

Average Gross Weight (lb)	Average Center-of-Gravity Fuselage Station (in.)	One-Inch Control Displacements											
		Longitudinal (deg in 1 sec)				Lateral (deg in 1/2 sec)				Directional (deg in 1 sec)			
		Specification[1] Minimum Angular Displacement		Test Angular Displacement		Specification[2]		Test		Specification[3]		Test	
		VFR	IFR	Aft	Forward	VFR	IFR	Left	Right	VFR	IFR	Left	Right
46,000	335 (aft)	1.25	2.04	5.0	4.8	0.75	1.12	2.5	3.5	3.05	3.05	2.0	2.0
APE II 46,000	319 (fwd)	1.25	2.04	4.7	6.7	0.75	1.12	2.0	2.2	3.05	3.05	N/R[4]	N/R
APE II 37,000	337 (aft)	N/A[5]	N/A	5.0	4.8	N/A	N/A	1.9	2.0	N/A	N/A	1.6	2.0
APE II 37,000	314 (fwd)	N/A	N/A	3.5	4.8	N/A	N/A	1.9	1.1	N/A	N/A	2.2	2.0

[1]Paragraphs 3.2.13 and 3.6.1.1 of MIL-H-8501A.
[2]Paragraphs 3.3.18 and 3.6.1.1 of MIL-H-8501A.
[3]Paragraphs 3.3.5 and 3.6.1.1 of MIL-H-8501A.
[4]Not recorded.
[5]Not applicable.

39. The IGE hover control power about the longitudinal and lateral axes met the requirements of the military specification. The directional control power did not meet the requirements of paragraph 3.3.5 and 3.6.1.1 of the military specification, in that the yaw displacement after 1 second following a rapid 1-inch step input was less than the specification requirement. However, within the scope of this test, the control power about all axes during hover is satisfactory for Army use. The normal acceleration and angular velocity response characteristics following longitudinal step inputs met the requirements of the military specification. The angular acceleration characteristics following longitudinal, lateral, and directional control displacements met the requirements of the military specification. The maneuvering stability and angular acceleration characteristics of the CH-47C allowed the pilot to easily and precisely control the helicopter and are satisfactory for Army use (HQRS 2).

40. The longitudinal controllability characteristics are presented as figures 31 through 35, appendix VI. The longitudinal control sensitivity of the helicopter was approximately 16 degrees per second per second (deg/sec^2) per inch of control travel. The control response varied from 6 to 8 deg/sec per inch of control travel. Control power varied between 3 to 5 degrees of pitch angular displacement in 1 second following a 1-inch input. Longitudinal controllability characteristics were independent of flight regime, configuration, or the PSA system mode selection. The longitudinal control response provided good aircraft control in the longitudinal axis and is satisfactory for Army use.

41. The lateral controllability characteristics are presented as figures 36 through 40, appendix VI. The lateral control sensitivity varied from 14 to 30 deg/sec^2 per inch of control travel, and the control response was approximately 10 deg/sec per inch of control travel. Control power was approximately 5 degrees of roll attitude change in 1 second following a 1-inch input. Lateral controllability characteristics were virtually independent of flight regime, configuration, or the PSA system mode selection. The lateral control response provided good aircraft control in the roll axis and is satisfactory for Army use. The requirements of the military specification were met.

42. The directional controllability characteristics are presented as figures 41 through 45, appendix VI. The directional control sensitivity was approximately 10 to 12 deg/sec^2 per inch of control travel, and the control effectiveness was approximately 10 to 12 deg/sec per inch of control travel. Control power was approximately 2 to 3 degrees of yaw attitude change in 1 second following a 1-inch input. Directional controllability characteristics were essentially independent of flight regime, configuration, or the PSA system mode selection. The directional control response provided good aircraft control in the yaw axis and is satisfactory for Army use.

43. In general, the controllability characteristics of the helicopter were similar to those reported in previous Army Preliminary Evaluations for similar gross weights and cg locations (refs 7 and 8, app I).

44. The control harmony was good for all flight regimes with no tendency to overcontrol. Within the scope of this test, the longitudinal, lateral, and directional controllability characteristics are satisfactory for Army use.

Control System Mechanical Characteristics

45. Control forces were measured with the helicopter on the ground (rotors not turning), with the auxiliary power unit (APU) supplying hydraulic pressure to the control system. Forces were measured with a hand-held force gage, and control positions were recorded from control position indicators. Control centering was ON, and the thrust control rod brake switch was depressed during thrust control rod measurements. The results of the control force measurements are presented as figures 46 through 49, appendix VI. A summary of the control breakout force, including friction recorded and detail specification requirements, is presented in table 2.

Table 2. Control Breakout Force Including Friction.

Control	Breakout Force Including Friction	
	Specification (lb)	Test (lb)
Longitudinal	0.5 to 2.0	0.6 forward 1.3 aft
Lateral	0.5 to 2.0	0.7 left 0.6 right
Directional	3.0 to 20.0	14.0 left 14.5 right
Collective (thrust)	1.0 to 10.0	2.0 up 1.5 down

46. The longitudinal control breakout force, including friction, was light and afforded precise control movement with minimum effort. The force gradient for the first inch of travel from trim was 0.9 pound per inch, aft, and 1.1 pounds per inch, forward. There were no undesirable continuities in the force gradient. The slope of the curve of stick force versus displacement was positive at all times, with the slope of the first inch of travel from trim approximately equal to the slope for the remaining stick travel. The longitudinal stick force characteristics met the requirements of the military and detail specifications and are satisfactory for Army use.

47. The lateral control breakout force, including friction, was light and afforded precise control movement with minimum effort. The force gradient for the first inch of travel from trim was approximately 0.9 pound per inch, both left and right. The slope of the curve of stick force versus displacement was positive at all times, and no undesirable continuities in the force gradient were apparent. The lateral stick force characteristics met the requirements of the military and detail specifications and are satisfactory for Army use.

48. The directional control force gradient was linear from breakout to the limit of control travel, and the limit force when trimmed with pedals neutral was 27.5 pounds to the left and 28.5 pounds to the right. There were no force gradient continuities. The directional control force characteristics met the requirements of the military and detail specifications and are satisfactory for Army use.

49. The thrust control rod breakout force, including friction, was measured with the thrust control magnetic brake released and from a position representative of an in-flight condition. Normal rates of control movement provided the pilot with a comfortable feel of the thrust control system. The thrust control rod force characteristics met the requirements of the detail specification and are satisfactory for Army use.

Simulated Engine Failures

50. Engine failures (single and dual) were evaluated by moving the engine condition lever to the ground idle position and observing the resultant helicopter response. Flight controls were held fixed as long as practical following the simulated failure.

51. Simulated single-engine failure evaluations were made at the conditions shown in table 3. The helicopter response was mild, with no rapid attitude changes that would require immediate recovery. The conditions of high airspeed and high engine torque resulted in the most extreme response to simulated single-engine failures. Time histories of simulated single-engine failures which demonstrate the most extreme response for a gross weight of approximately 33,000 pounds, are presented as figures 50 and 51, appendix VI. With the PSA system ON, pitch attitude was regained following a slow, small, nose-up pitch change, and the helicopter slowly rolled to the left at a rate that was easily controlled by the pilot. The roll rate was slightly higher with simulated failure of the left engine. With the PSA system OFF, a slow divergent nose-up pitch change resulted, but was easily controlled by the pilot. Figure 52 depicts the typical response at a gross weight of 44,450 pounds. Response characteristics at this gross weight were less severe than those at 33,000 pounds. Following the single-engine failure, the operating engine increased power until reaching maximum power available. The subsequent rotor speed reduction varied according to the initial engine torque setting. The thrust control rod had to be lowered to prevent rotor speed reductions in excess of 20 rpm only above dual-engine torque settings of approximately 70 percent. The rotor speed decrease provided an adequate audio cue to the pilot of engine failure Within the scope of these tests, the simulated single-engine failure characteristics met the requirements of the military specification and are satisfactory for Army use.

Table 3. Single-Engine Failure Test Conditions.

Average Calibrated Airspeed (kt)	Average Gross Weight (lb)	Average Center-of-Gravity Fuselage Station (in.)	Initial Rotor Speed (rpm)	Average Density Altitude (ft)	Initial Indicated Engine Torque (%)		Pitch Stability Augmentation System
					No. 1	No. 2	
91	32,600	335.5 (aft)	235	4,500	38	38	NORM and OFF
131	32,400	338.5 (aft)	236	5,200	63	63	NORM and OFF
152	32,150	338.6 (aft)	235	5,200	78	78	NORM and OFF
Zero (approx)	31,850	339.0 (aft)	235	4,850	53	53	NORM and OFF
87	31,650	339.0 (aft)	235	5,400	78	78	NORM and OFF
136	32,650	338.6 (aft)	235	5,000	78	78	AUTO
143	32,650	338.7 (aft)	235	5,130	78	78	NORM and OFF
52	44,100	335.6 (aft)	245	3,000	53	53	NORM and OFF
84	44,560	336.3 (aft)	245	4,880	61	60	NORM and OFF
102	44,320	336.4 (aft)	245	5,100	67	68	NORM and OFF
Zero (approx)	46,100	335.4 (aft)	244	4,740	80	80	NORM and OFF

52. Simulated dual-engine failure evaluations were made at the conditions shown in table 4. Response of the helicopter following simulated dual-engine failures at speeds greater than 100 KCAS was more severe than following simulated single-engine failures. At airspeeds of 100 KCAS or less, the responses were similar to the single-engine failure response. The nose-up pitch change following a dual-engine failure was adequately corrected by the PSA system (fig. 53, app VI). With the PSA system OFF, correction of the divergent nose-up pitching required a slightly faster pilot reaction than was required with single-engine failure, but presented no aircraft control problem (fig. 54). Lateral and directional oscillations were apparent following failures at airspeeds in excess of 140 KCAS, but did not limit control of the aircraft. Following simulated dual-engine failures, the rapid rotor speed decay provided an unmistakable cue to the pilot. Transient rotor speed decay to 190 rpm was experienced with no apparent degradation in control response. Time delays from engine failure to collective control reduction were slightly in excess of 1 second for transient rotor speed decay to approximately 190 rpm. Within the scope of this test, simulated dual-engine failure response characteristics are satisfactory, and delay time between engine failure and collective control movement met the requirements of the detail specification.

Stability Augmentation System Failures

53. Dual SAS failures were qualitatively evaluated throughout the flight envelope. Pilot effort required to retain control of the helicopter varied according to the degree of pilot preoccupation with other tasks and the amount of turbulence affecting the helicopter at the time of failure. Under VFR conditions, the pilot was able to retain control of the helicopter with moderate effort (HQRS 4). The SAS-OFF flight characteristics are such that extended flight and safe landings could be accomplished under VFR conditions. Flight under simulated IFR conditions with the SAS OFF required considerable pilot effort to satisfactorily control the helicopter and left no time to devote to other tasks (HQRS 8). Flight under IFR conditions with both SAS inoperative is of such a degree of difficulty that it would constitute an emergency condition. To preclude such a condition from occurring, intentional flight in IFR conditions with one SAS inoperative should be prohibited.

54. Simulated single-SAS hardover failures were qualitatively evaluated in hover and at forward speeds up to 135 KCAS with and without the remaining SAS operating. Unannounced failures were introduced separately in the number-one longitudinal, lateral, and directional SAS with a pulser box. Simulated SAS hardover failure with the second SAS operating presented no problem in aircraft control. Without the second SAS operating and under VFR conditions, the pilot was able to regain control of the helicopter following a SAS hardover, even when engaged in other cockpit tasks. Pilot effort required to regain and maintain control of the helicopter following the failure was least with failure of the lateral SAS, and greatest with failure of the directional SAS. Without the second SAS operating, pilot effort required to control the helicopter following a SAS hardover failure would be significantly increased under IFR conditions, and intentional flight in IFR conditions with one SAS inoperative should be prohibited. The following "WARNING" should be placed in the operator's manual:

Table 4. Dual-Engine Failure Test Conditions.

Average Calibrated Airspeed (kt)	Average Gross Weight (lb)	Average Center-of-Gravity Fuselage Station (in.)	Initial Rotor Speed (rpm)	Average Density Altitude (ft)	Initial Indicated Engine Torque (%)		Pitch Stability Augmentation System
					No. 1	No. 2	
78	33,230	338.0 (aft)	235	5,320	88	0	NORM
76	33,020	338.1 (aft)	235	4,950	0	88	OFF
78	33,050	338.1 (aft)	235	5,800	76	76	NORM and OFF
129	32,360	338.8 (aft)	235	5,000	71	71	NORM
145	32,690	338.3 (aft)	236	5,180	74	72	OFF
148	32,850	338.2 (aft)	235	5,250	78	78	NORM
78	45,180	335.8 (aft)	244	7,240	77	77	OFF
104	44,050	335.8 (aft)	245	5,000	62	62	OFF

WARNING

During flight in IFR conditions with only one SAS operating, failure of that SAS could result in loss of aircraft control.

MISCELLANEOUS

Engine Torque Split

55. One case of excessive engine torque split occurred during this test program. The gross weight of the helicopter was 44,000 pounds, with a cg at FS 336.6, which included a 10,000-pound external sling load suspended 10 feet below the helicopter. The density altitude was 5,000 feet, and outside air temperature (OAT) was 14°C. At the time of the occurrence, engine torque was approximately 65 percent and rotor speed was 245 rpm, and neither the pilot nor the copilot were manipulating the normal engine control (beep) switch. When the torque split occurred, a maximum torque difference of 22 percent was observed when the number-one engine torque indicated 44 percent and the number-two engine torque indicated 66 percent. Torques were subsequently matched using the beep control. An Equipment Performance Report (EPR) (ref 12, app I) was submitted on 1 June 1971. No other occurrence of this condition was observed nor could one be duplicated during the stability and control testing. Safety of flight was not a factor during this occurrence of torque split. However, under flight conditions requiring maximum power available, such as takeoff or landing over obstacles, a torque split of this magnitude would cause the helicopter to contact the obstacle. An investigation should be made to determine the cause of torque splits with the T55-L-11A engines. Correction of this deficiency, excessive torque split with T55-L-11A engines in the CH-47C, is mandatory prior to operational use.

Thrust Control Rod Slippage

56. The inability of the thrust control magnetic brake to maintain a precise selected control setting was observed throughout these tests. This condition was observed at all power settings and flight conditions, and was most apparent to the pilot when the thrust control rod was raised for increased power. After the desired engine torque setting was reached, the magnetic brake trigger released, and the applied force relaxed, engine torque decreased 2 to 3 percent. This resulted in excessive time and attention being required to select a precise engine torque (HQRS 4). When maximum power was required, the pilot either initially overtorqued 2 to 3 percent or held a continuous force on the thrust control rod. Correction of the excessive thrust control rod slippage is desirable for improved operation and mission capabilities.

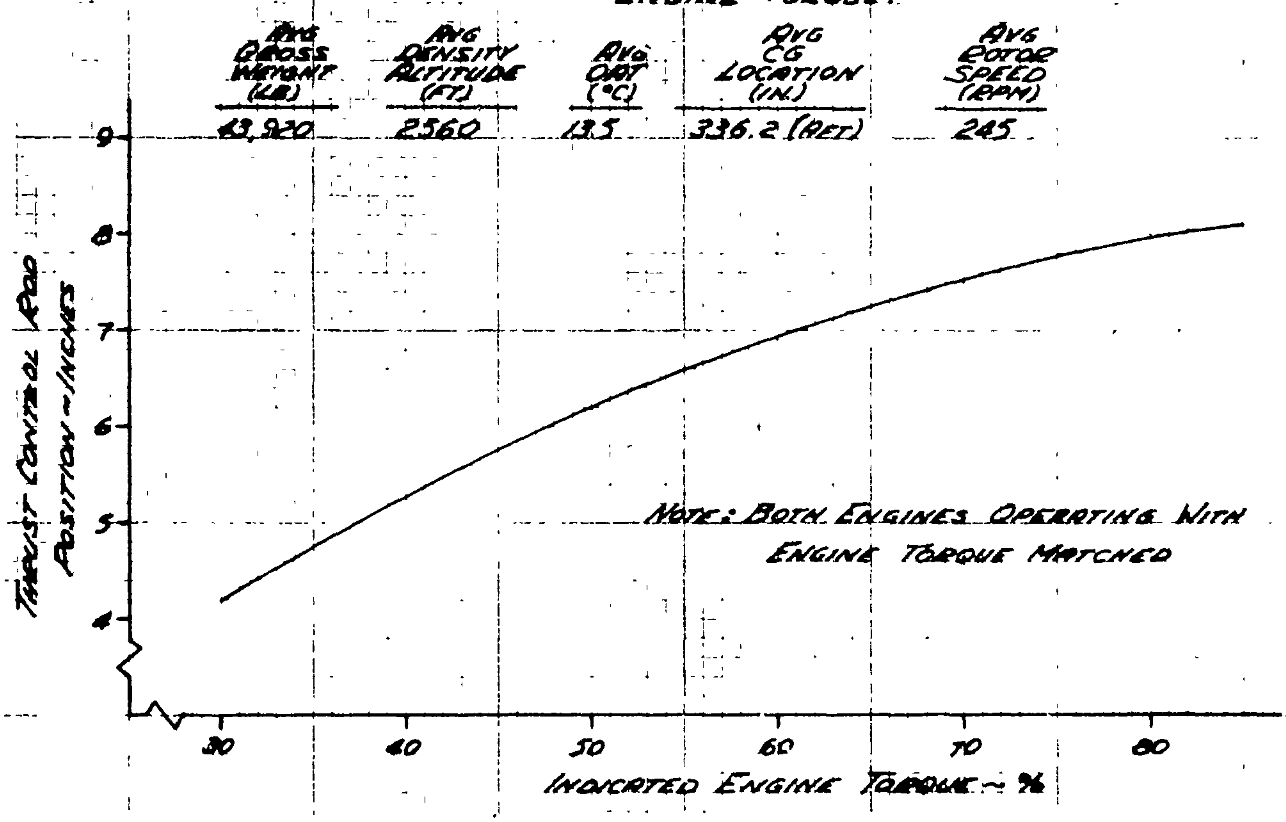
Engine Thrust Control Rod Characteristics

57. The thrust control rod position characteristics in relation to indicated engine torque are presented as figure B. Thrust control rod positions were recorded by

the oscillograph at stabilized values of matched engine torque, beginning on the ground and terminating in a slight vertical climb. Test conditions are listed in figure B. At a 50-percent engine torque, the engine response to thrust control rod displacement was approximately 13 percent per inch and increased to approximately 18 percent per inch at a 70-percent engine torque. At torque settings of less than 70 percent, precise torque selection was easily accomplished by manipulation of the thrust control rod. At torque settings above 70 percent, engine torque was overly sensitive to thrust control rod movement. During operations at high gross weights, engine torque above 70 percent was frequently required. Pilot corrections to gust upsets usually required several movements of the thrust control rod to correct for the change. Overshoots in selecting a new engine torque setting were common, and when operating near the published torque limits (78 percent), an increase in attention was required to prevent transient overtorques. Moderate pilot effort was required above a 70-percent engine torque to stay within the operating torque limit (HQRS 4). Correction of the excessive engine torque change with thrust control rod displacement at or above engine torque settings of 70 percent is desirable for improved operation and mission capabilities.

(Figure B)

Figure B. Thrust Control Rod vs Engine Torque.



Acceleration and Deceleration Characteristics

58. Aircraft acceleration and deceleration characteristics were qualitatively evaluated at a gross weight of 33,000 pounds, an aft cg, a density altitude of 3,700 feet, and an OAT of 22°C, and also at a gross weight of 46,000 pounds, an aft cg, a density altitude of 2,500 feet, and an OAT of 12°C. During the acceleration and deceleration, a height of 20 to 30 feet was maintained. Time and approximate distance required to accelerate and decelerate between hover and 110 KCAS were recorded. At the lighter gross weight, an average of 18 seconds and a distance of 2,000 feet were required to accomplish the acceleration or deceleration. The acceleration at the higher gross weight required 45 seconds and 5,000 feet, while the deceleration took 30 seconds and 3,100 feet. The acceleration and deceleration characteristics of the CH-47C met the requirements of the military specification and are satisfactory for Army use.

Structural Load Indicator

59. A cruise guide indicator (CGI) was used during the stability and control testing of the CH-47C helicopter. The CGI is a direct display of the structural loads in critical helicopter components. These loads and the conditions which cause them did not always produce recognizable cues to the pilot. The CGI display allows the pilot to take corrective action, usually in the form of airspeed, power, or bank angle reduction, when the structural limits on these components are approached. Structural loads and indications on this display increased as gross weight, airspeed, and bank angle increased. Turbulence and abrupt control movements caused transient increases in the structural loads and CGI indications. Turning flight above the 80-percent limit forward airspeed in moderate turbulence at a 46,000-pound gross weight caused transient CGI readings that were in excess of the allowable limits. Reduction of airspeed or bank angle resulted in CGI indications within limits. The CH-47C helicopter should be equipped with a structural load indicator to warn the pilot when limits on critical components are reached.

Autorotational Landing Distance

60. Autorotational landing distances were determined by landing the helicopter on a smooth paved surface at a gross weight of approximately 33,000 pounds. Engine condition levers were left in the FLIGHT position, and engine beep was decreased for approximately 1 second following entry to the autorotation. Touchdown speed was estimated by taking an average of the indicated boom airspeed corrected to true airspeed and the ground speed of a pace vehicle. Target touchdown speed was 35 knots. The landing technique used was to land the helicopter on the aft gear and allow the front gear to contact the ground prior to application of wheel brakes. Rotor speed was maintained below 250 rpm during the flare. Average conditions at the landing site were a pressure altitude of 2,300 feet and an OAT of 12°C. A landing roll distance of 300 feet was achieved. This distance met the requirements of the detail specification.

Ground Taxi

61. Taxiing with power steering required two pilots. One pilot operated the flight controls while the other pilot operated the power steering control knob. This prevented either pilot from performing other necessary tasks such as copying an instrument clearance or tuning radios while the helicopter was being taxied. Correction of the inability to safely ground taxi with power steering while performing other cockpit tasks is desirable for improved operation.

62. When the helicopter was taxied with power steering at light gross weights (less than 30,000 pounds), it was possible for the aft right landing gear to become airborne, which caused a loss of power steering control. Correction of the loss of power steering control at light gross weights is desirable for improved operation.

63. Ground taxi of the CH-47C with the power steering OFF can be accomplished with moderate pilot effort when using the technique recommended in the operator's manual. Ground taxi without power steering is an alternate method which can be used at all operational gross weights whenever the power steering becomes inoperative.

Speed Trim Function Switch

64. The longitudinal cyclic speed trim function switch is located on the center console within easy reach of the pilot. The two-position function switch selects either automatic programming or manual operation of the speed trim actuators. When manual operation is selected, the forward and aft speed trim actuators are operated by individual switches near the function switch. Should the function switch be placed in the position for manual operation and the aircraft flown from hover to speeds over 120 KIAS, excessive loads will be imposed on the aft rotor shaft. The PSA mode switch is located on the center console 3 inches forward of the speed trim function switch and is identical in size and operation. With the present switch configuration, inadvertent operation of the longitudinal cyclic speed trim function switch to the manual position could be easily made by the pilot and cause damage to helicopter components. The possibility of inadvertent actuation of the longitudinal cyclic speed trim switch should be corrected for improved operation and mission capabilities. A guarded switch would prevent inadvertent operation.

CONCLUSIONS

GENERAL

65. The following conclusions were reached upon completion of the airworthiness and flight characteristics stability and control tests of the CH-47C helicopter:

a. Stability and control characteristics of the CH-47C are acceptable for the transport helicopter mission.

b. One deficiency and 12 shortcomings were found.

DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

66. Correction of the excessive torque split deficiency with T55-L-11A engines in the CH-47C is mandatory (para 55).

67. Correction of the following shortcomings is desirable for improved operation and mission capabilities:

a. Poor trimmability characteristics (HQRS 4) (para 14).

b. Uncommanded pitch attitude change associated with retrimming operations when the PSA system is in the NORMAL mode (HQRS 5) (para 15).

c. Excessive pilot effort required to maintain trim airspeed (HQRS 5) (para 17).

d. Undesirable pitch attitude changes resulting from thrust control rod changes (HQRS 4) (para 20).

e. Poor static longitudinal stability characteristics with the PSA system OFF (para 23).

f. Poor high-speed maneuvering characteristics (HQRS 5) (para 28).

g. Poor maneuvering flight characteristics with the PSA system operating in the AUTO mode (para 30).

h. Excessive thrust control rod slippage (HQRS 4) (para 56).

i. Excessive engine torque change with thrust control rod displacement at or above engine torque settings of 70 percent (HQRS 4) (para 57).

j. Inability to safely ground taxi with power steering while performing other cockpit tasks (para 61).

k. Loss of power-steering control at light gross weights (para 62).

l. The possibility of inadvertent actuation of the longitudinal cyclic speed trim function switch (para 64).

SPECIFICATION COMPLIANCE

68. Within the scope of these tests, the stability and control characteristics of the CH-47C met the requirements of the military specification or deviations of the detail specification, except as listed below:

a. Deviations 5 and 11 of the detail specification – the gradient of the longitudinal control position with respect to airspeed was not positive for any conditions tested with the PSA system OFF (para 23).

b. Paragraphs 3.2.11 and 3.6.1.2 of the military specification – with the PSA system OFF, the pitch response to simulated gust inputs was aperiodically divergent (para 32).

c. Paragraphs 3.3.5 and 3.6.1.1 of the military specification – the yaw displacement after 1 second following a rapid 1-inch step input was less than required (para 39).

RECOMMENDATIONS

69. Correction of the deficiency is mandatory prior to operational use.

70. The shortcomings should be corrected at the earliest possible time.

71. The following "NOTE" should be placed in the operator's manual (para 15):

NOTE

> To preclude the occurrence of uncommanded pitch attitude changes when operating with the PSA system in the NORMAL mode, depress the centering device release button prior to initiating an attitude or airspeed trim change, and release the button only after achieving the new flight condition.

72. As an interim measure, thrust control rod changes should be made slowly to minimize pilot effort to maintain airspeed during power changes (para 20).

73. Intentional flight in IFR conditions should be prohibited with one SAS inoperative (paras 53 and 54).

74. The following "WARNING" should be placed in the operator's manual (para 54):

WARNING

> During flight in IFR conditions with only one SAS operating, failure of that SAS could result in loss of aircraft control.

75. An investigation should be made to determine the cause of the torque split deficiency with T55-L-11A engines installed (para 55).

76. The CH-47C helicopter should be equipped with a structural load indicator to warn the pilot when limits on critical components are approached (para 59).

APPENDIX I. REFERENCES

1. Report, The Boeing Company, Vertol Division, Number D8-0314, *CH-47 Product Improvement Program Configuration IA and II*, 24 May 1966.

2. Letter, TECOM, AMSTE-BG, 17 June 1966, subject: Test Directive, Product Improvement Test, CH-47C Helicopter.

3. Letter, AVSCOM, AMSAV-R-FT, 29 April 1969, subject: CH-47C Airworthiness and Flight Characteristics Test (66-29).

4. Test Plan, USAASTA, Project No. 66-29, *Engineering Flight Test, CH-47C Helicopter (Chinook), Airworthiness and Flight Characteristics Tests*, August 1969.

5. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities, General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.

6. Specification, The Boeing Company, Vertol Division, Number 114-PJ-803, *Detail Specification for the Model CH-47C Helicopter*, 7 December 1967, with Revision A, 15 May 1969.

7. Final Report, USAASTA, Project No. 66-28, *Engineering Flight Test of the YCH-47C Medium Transport Helicopter, Army Preliminary Evaluation II*, February 1969.

8. Final Report, USAASTA, Project No. 66-28, *Army Preliminary Evaluation III and IV, YCH-47C Medium Transport Helicopter*, July 1970.

9. Letter, USAASTA, SAVTE-TA, 3 February 1971, subject: Revised Test Plan for the Stability and Control Portion of Project 66-29 (CH-47C A&FC Test Program).

10. Technical Manual, TM 55-1520-227-10, *Operator's Manual, Army Model CH-47B and CH-47C Helicopters*, April 1969, with changes through June 1969.

11. Equipment Performance Report, USAASTA, SAVTE-TA, EPR 66-29-01, Project No. 66-29, "CH-47C A&FC Stability and Control," 2 July 1970.

APPENDIX II. AIRCRAFT CHARACTERISTICS

GENERAL DIMENSIONS

Length (fuselage)	51.0 ft
Length (overall)	99.0 ft
Height	18.7 ft
Width of cabin	9.0 ft
Tread (fwd gear)	10.5 ft
Tread (aft gear)	11.2 ft
Rotor diameter	60.0 ft
Rotor solidity	0.067
Number of rotors	2
Blades per rotor	3
Disc area (total)	5,655 ft^2
Swept area (total)	5,000 ft^2 (approx)

WEIGHT DATA

Empty weight (specification)	20,420 lb
Design gross weight	33,000 lb
Alternate design gross weight	46,000 lb

CENTER-OF-GRAVITY REFERENCE

Center-of-gravity reference	FS 331.0 (centerline between rotors)

Forward limit (from cg reference)	30.0 in. forward (28,500 lb and below
Aft limit (from cg reference)	18.0 in. aft (28,500 lb and below

T55-L-11A ENGINE RATINGS (sea level)

Maximum power	3,750 shp
Military rated power	3,400 shp
Normal rated power	3,000 shp

OPERATING ROTOR SPEED

Gross weights of 40,000 pounds or less	235 rpm
All gross weights (normally used only above 40,000 pounds)	245 rpm

APPENDIX III. FLIGHT CONTROL DESCRIPTION

GENERAL

1. The flight control system is irreversible and is powered by two independent hydraulic boost systems, each operating at a 3,000-psi pressure. Operation of the helicopter is not possible unless one of the boost systems is in operation to counteract aerodynamic loads on the rotors.

CONTROL SURFACES

Type of Control Surfaces

2. The movable control surfaces consist of six main rotor blades, three mounted on each rotor head. The forward and aft rotor heads are in tandem along the longitudinal axis of the helicopter (fig. AA, app II). The forward rotor blades are individually interchangeable and the aft rotor blades are individually interchangeable. The rotor heads are fully articulated, which permits blade movement about the pitch, flap, and lead/lag axes. The airfoil section designation and thickness is modified Ames droop snoot ($t/c = 0.10$), and the blades are of rectangular planform with a radius of 30 feet and a chord of 25.25 inches.

Limits of Control Travel

3. The allowable pitch change movements of the control surfaces are described in table A of this appendix.

Control Functions

4. In the tandem rotor configuration, control about all axes is achieved through combinations of cyclic and collective pitch variations on the forward and aft rotor systems.

Longitudinal

5. The helicopter is controlled longitudinally through application of differential collective pitch (DCP) by fore and aft movement of the cyclic control. Collective pitch on the forward rotor is decreased, while collective pitch on the aft rotor is increased to provide nose-down pitch. The opposite occurs for nose-up movement.

Lateral

6. Both rotor planes are tilted in the desired direction of turn by cyclic variation of blade pitch angle through left or right movement of the cyclic control stick.

Table A. Allowable Pitch Change Movements.

Control	Blade Pitch
Longitudinal control (differential collective blade pitch)	±4 degrees
Lateral cyclic blade pitch	±8 degrees
Directional control (differential lateral cyclic blade pitch)	±11.43 degrees
Thrust control rod pitch	1 to 18 degrees
Maximum simultaneous directional plus lateral control	16.5 degrees, forward rotor 16.5 degrees, aft rotor
Stick trim (differential collective blade pitch)	±1 degree

Directional

7. The rotor planes are tilted laterally in opposite directions through application of the directional control pedals. During turns to the left the forward rotor tilts left, while the aft rotor tilts to the right. The opposite occurs during turns to the right.

Vertical

8. The collective pitch on the fore and aft rotors is changed by an equal amount to affect altitude changes by application of the thrust control rod.

COCKPIT CONTROLS

Limits of Cockpit Control Travel

9. The limits of cockpit control movement are shown in table B of this appendix.

Stick Centering and Feel

10. Flight control feel is introduced artificially through the use of centering springs and magnetic brakes connected to the flight bell cranks and control rods. When a switch on either cyclic stick grip is depressed, the longitudinal, lateral, and directional centering devices are released and allow the cyclic stick and directional

pedals to be repositioned to obtain a new flight attitude and corresponding control position. Releasing the switch removes electrical power which applies the magnetic brakes and reengages the centering springs with the controls positioned in the new center of reference. On helicopters equipped with the pitch stability augmentation (PSA) system, when either of the centering device release switches are depressed, the PSA system is deactivated if the PITCH STAB AUG switch is at AUTO SYNC or NORMAL SYNC. The artificial feel centering device springs, on all controls, may be manually overcome at any time; however, when the control pressure is released, the controls will return to their original position. A trigger-type switch on each thrust control rod grip controls a magnetic brake that holds the thrust control rod in place when no movement is desired.

Table B. Cockpit Control Limits.

Control	Total Control Travel
Longitudinal cyclic	6.4 in. aft to 7.7 in. forward
Lateral cyclic	4.04 in. left to 4.2 in. right
Directional pedal	4.13 in. left to 4.15 in. right
Thrust control rod	9.8 in.

Longitudinal Stick Positioner

11. A longitudinal stick positioning wheel is installed to allow the pilot to position the cyclic stick fore and aft to compensate for various center-of-gravity conditions. No motions are imparted by the trim wheel to the flight control system and the wheel is not capable of aerodynamically trimming the helicopter.

STABILITY AUGMENTATION SYSTEM

12. Two complete stability augmentation systems (SAS) are installed in the CH-47C helicopter. The system is designed so that both SAS are used simultaneously with each operating at half gain. During dual operation, if a single SAS failure occurs, the operating SAS automatically functions at full gain, producing no significant change in control feel or response. The SAS automatically maintains stability about the pitch, roll, and yaw axes and functions to permit coordinated (cyclic only) turns at speeds above 40 KIAS. The SAS channels receive bank angle signals from the vertical gyros. Limited roll attitude stability is provided for bank angles up to 5 degrees in either direction. The basic components of the SAS are three dual extensible links, two SAS amplifiers, three gyros for sensing angular rates, pressure transducers used for sensing sideslip, and various control switches and caution lights. Corrective signals from each gyro or sensor are fed into the control system differentially through the SAS extensible links, whereby the rotor

head controls move without producing movements of the cockpit controls. By this method, the requirement for only limited control authority is possible. The pilot can override a malfunctioning SAS should a hardover signal occur.

DIFFERENTIAL COLLECTIVE PITCH TRIM

13. A fully automatic DCP trim system is incorporated in the flight control system to improve longitudinal control position characteristics with airspeed. The DCP actuators program aft differential collective pitch with increasing airspeed and forward differential collective pitch with decreasing airspeed. The basic components of the DCP trim system are the DCP actuator, the speed trim amplifier, and the pitot system. The DCP trim system converts airspeed information from the pitot system through the speed trim amplifier to an electrical signal which controls extension or retraction of the DCP actuator. The DCP trim system is automatically programmed between 40 and 160 knots.

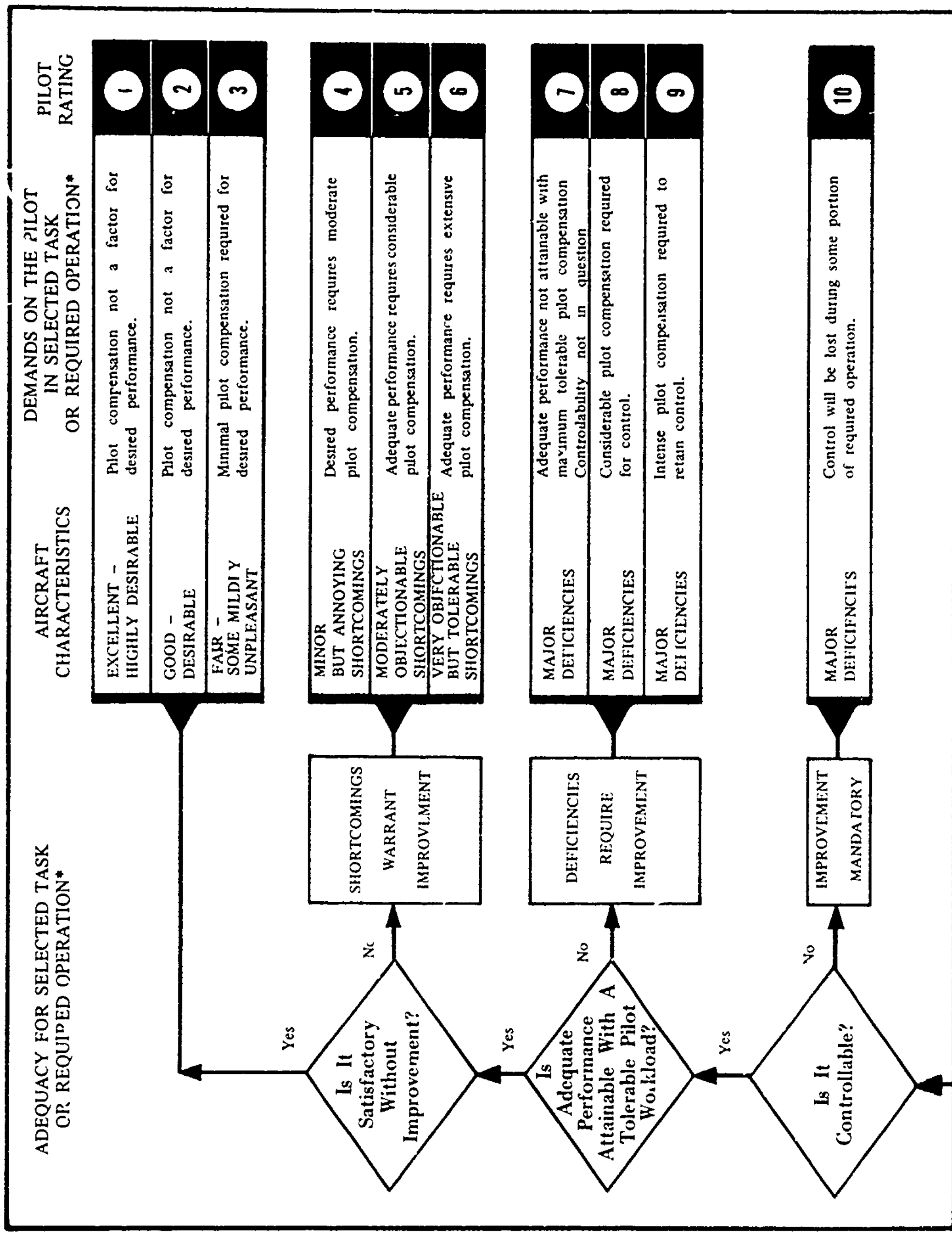
LONGITUDINAL CYCLIC SPEED TRIM

14. A longitudinal cyclic speed trim system which can be operated either manually or automatically is incorporated in the flight control system. The longitudinal cyclic speed trim system reduces the angle of attack of the fuselage relative to the airstream as forward airspeed is increased, thus reducing fuselage drag. The system also reduces rotor blade flapping, which results in lower stresses in the rotor shafts. A longitudinal cyclic speed trim actuator is installed under each of the swashplates. Signals are automatically transmitted to these actuators by either the speed trim amplifier (control box) or by pilot-commanded signals from the manual longitudinal cyclic speed trim switches on the console. The cyclic trim indicators are mounted on the center instrument panel, and the control switches are located on the console.

PITCH STABILITY AUGMENTATION SYSTEM

15. A PSA system is incorporated into the flight control system to improve airspeed and pitch stability. The copilot's vertical gyro and the pitot system provide inputs, through the speed trim amplifier, to the DCP trim actuator when operating in the NORMAL or AUTO SYNC mode. The CH-47C is equipped with a three-position (OFF/NORMAL/AUTO) PSA system mode selection switch. The NORMAL mode provides a continuous signal, equivalent to 0.13 inch of longitudinal cyclic per degree of pitch attitude change and 0.07 inch of longitudinal cyclic per knot of airspeed change about trim, to the DCP, regardless of the cyclic control position. In the AUTO mode, the PSA system operates in the same manner as the NORMAL mode, providing that the cyclic is not moved more than one-eighth of an inch forward or aft of its trim position. Motion beyond these limits causes automatic deactivation of the PSA system. Upon deactivation of the PSA system, the longitudinal static and dynamic stability is then provided only by the SAS.

APPENDIX IV. HANDLING QUALITIES RATING SCALE



[1]Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) And Definitions In Accordance With AR 310-25

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions

APPENDIX V. TEST INSTRUMENTATION

COCKPIT PANEL

Boom airspeed
Ship's system airspeed
Rotor speed
Boom altitude
Ship's system altimeter
Angle of sideslip
Angle of attack
Longitudinal control position
Lateral control position
Directional control position
Thrust control rod (collective control) position
Cruise guide indicator

PHOTOPANEL

Boom airspeed
Ship's system airspeed
Rotor speed
Gas producer speed (N_1) (both engines)
Boom altitude
Ship's system altimeter
Free air temperature
Fuel temperature (both engines)
Fuel counter (both engines)
Engine torque (both engines)
Rate of climb/descent
Time of day
Correlation counter
Camera counter
Record coder (both oscillographs)
Event switch
Pilot event light
Engineer event light

OSCILLOGRAPH NO. 1

Engineer event
Pilot event
Rotor blip
Engine fuel flow (both engines)
Aft pivoting link actuator
Aft fixed link actuator
Cruise guide indicator
Photopanel camera blip

OSCILLOGRAPH NO. 2

Engineer event
Pilot event
Rotor blip
Boom airspeed
Pitch attitude
Pitch rate
Pitch acceleration
Roll attitude
Roll rate
Roll acceleration
Yaw attitude
Yaw rate
Yaw acceleration
Pitch SAS (both channels) (No. 1 and No. 2)
Roll SAS (both channels)
Yaw SAS (both channels)
Longitudinal control position
Lateral control position
Directional control position
Thrust control rod (collective control) position
Throttle position (both engines)
Differential collective pitch (DCP)
speed trim position
Forward cyclic speed trim position
Angle of attack
Angle of sideslip
Gas producer speed (N_1) (both engines)
CG normal acceleration
Linear rotor speed
Photopanel camera blip

APPENDIX VI. TEST DATA

INDEX

FIGURE 1
TRIM CONTROL POSITIONS IN LEVEL FLIGHT
CH-47C USA S/N 68-15859

SYMBOL	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN)	AVG ROTOR SPEED (RPM)	AVG C_T	ASE MODE
△	44,900	4670	18.4	333.8 (AFT)	245	.006518	AUTO
○	45,610	4940	17.9	333.5 (AFT)	245	.006636	NORMAL
□	46,390	4850	17.9	333.2 (AFT)	245	.006731	OFF

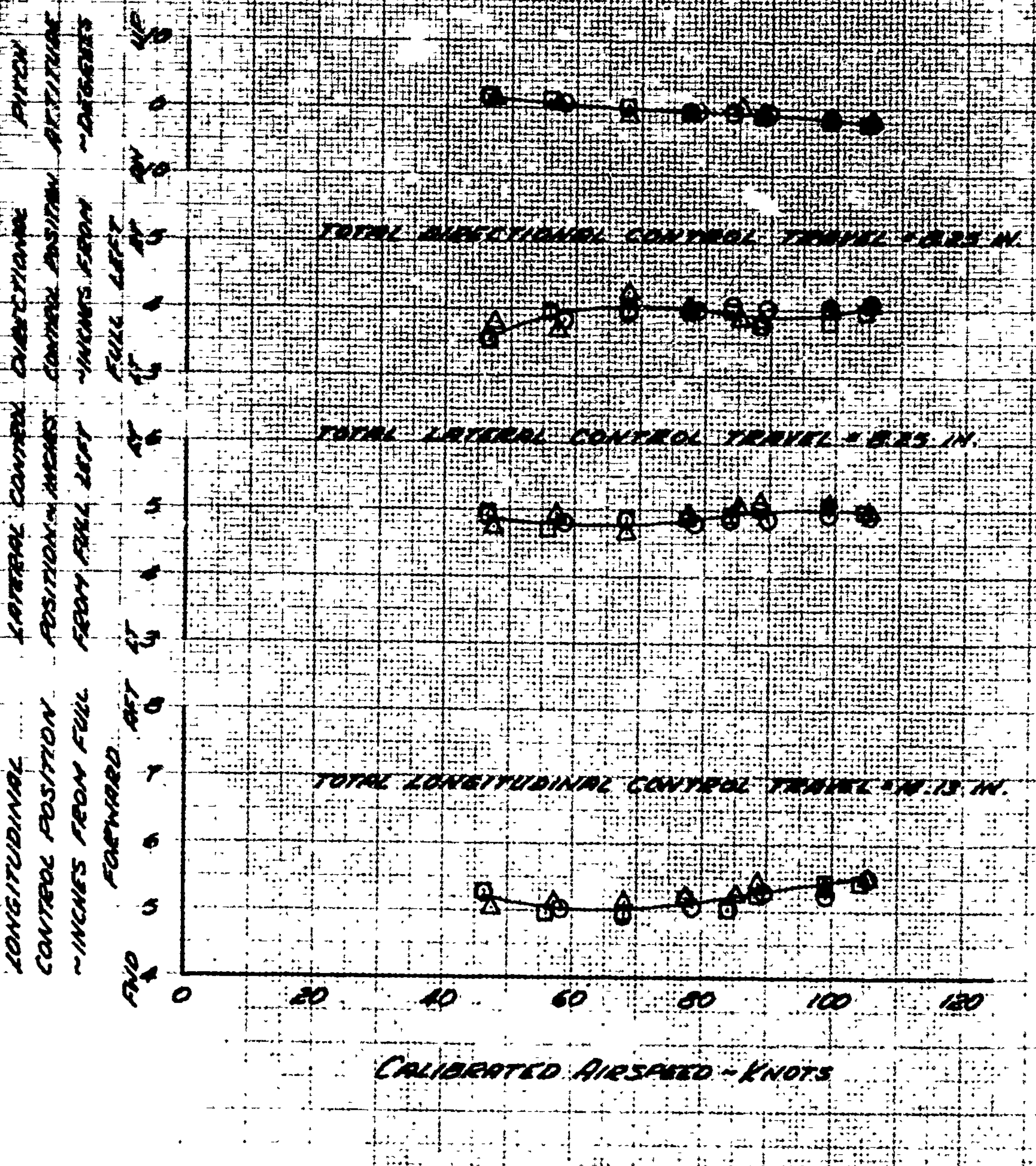


FIGURE 2

TRIM CONTROL POSITIONS IN LEVEL FLIGHT

CH-47C USA S/N 68-15859

AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T
33,650	4860	14.6	337.7 (AFT)	235	.005308

NOTE: PSA ~ NORMAL MODE

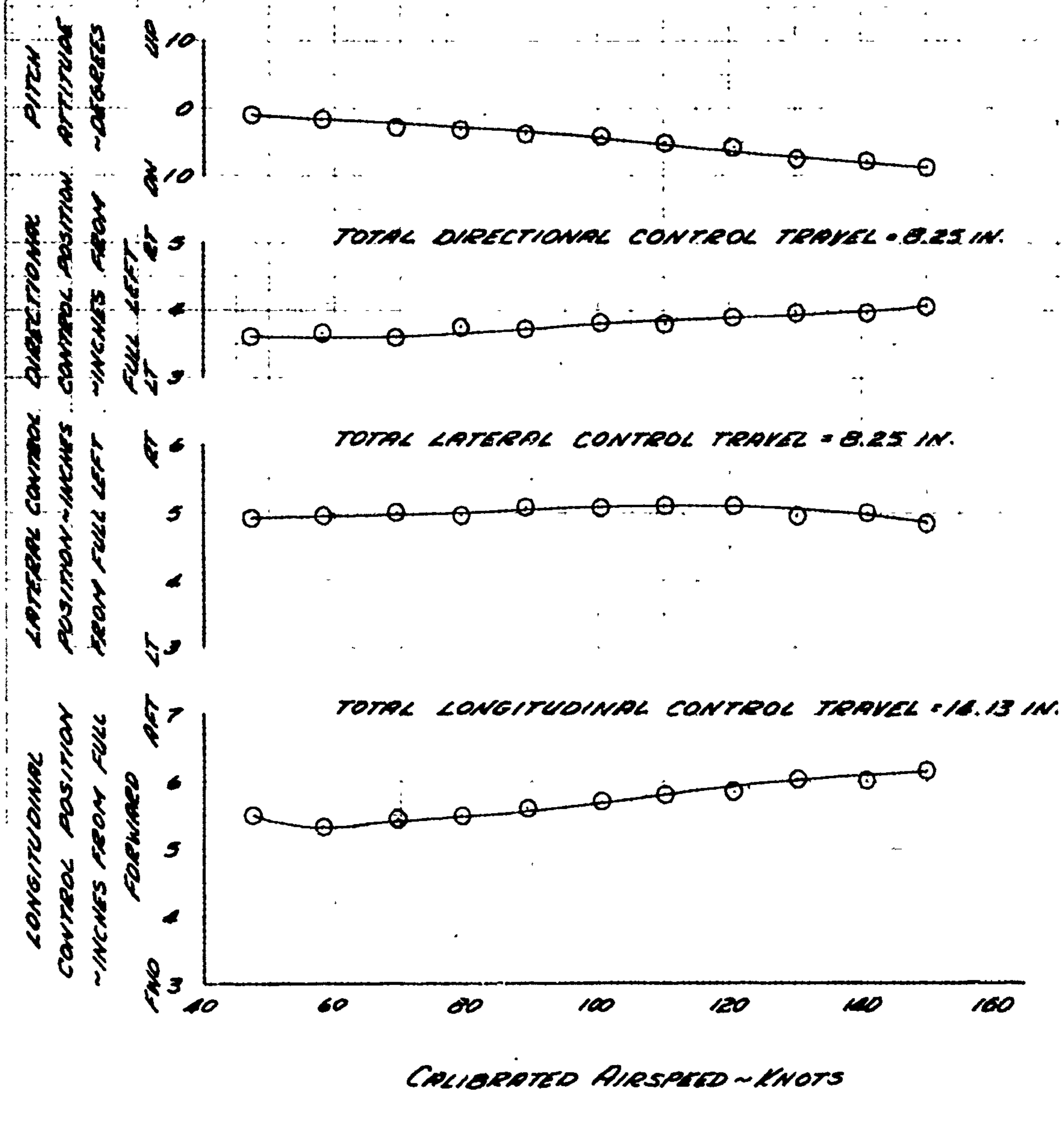


FIGURE 3
TRIM CONTROL POSITIONS IN LEVEL FLIGHT
CH-47C USA S/N 68-15859

AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN)	AVG ROTOR SPEED (RPM)	AVG C_T
43,810	4860	19.2	335.6 (AFT)	245	.005645

NOTE: 1. PSA ~ NORMAL MODE
2. 10,000 POUND SLING LOAD

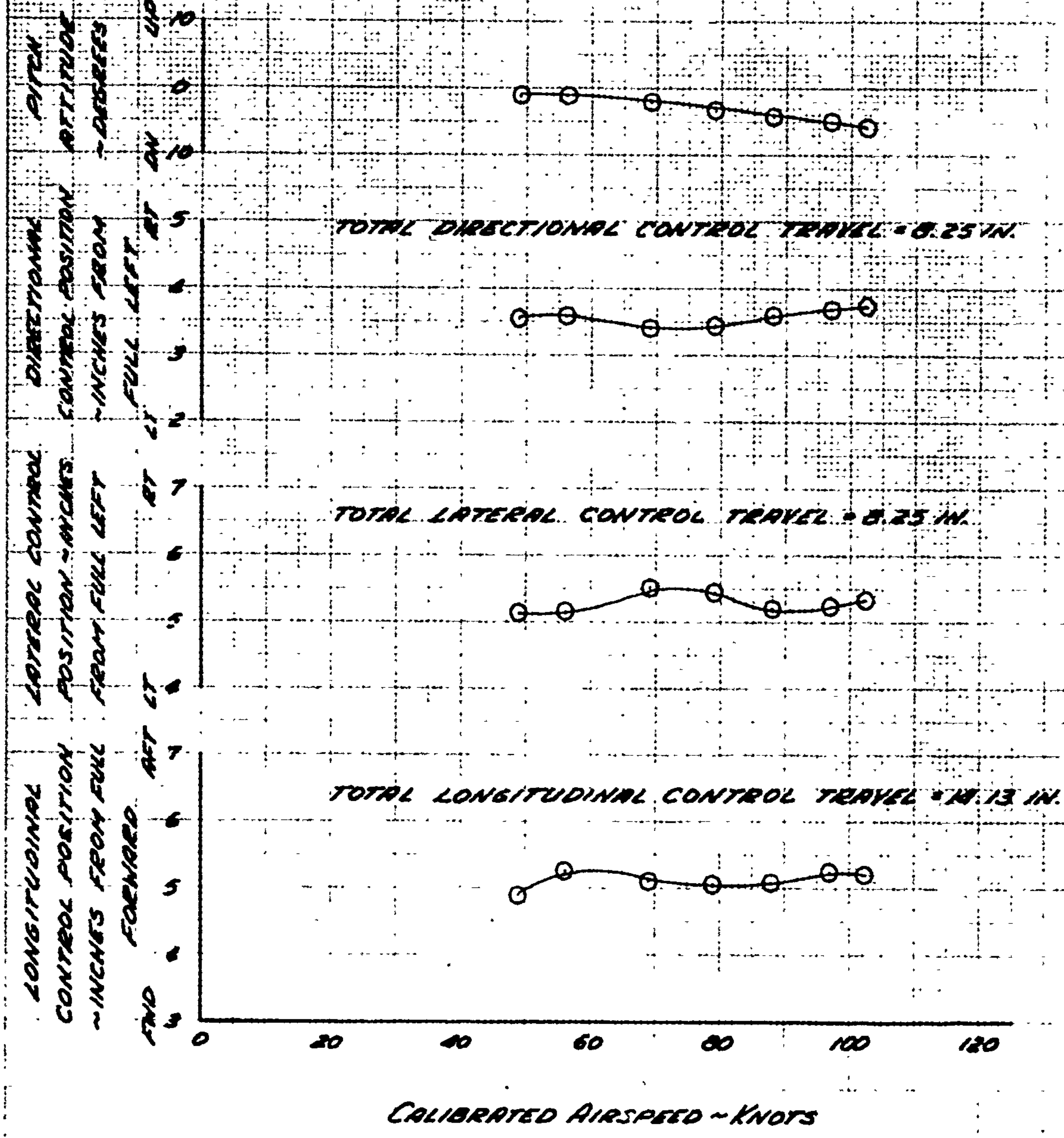


FIGURE 4
TRIM CONTROL POSITIONS IN LEVEL FLIGHT
CH-47C USA S/N 68-15859

AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T
45,910	8260	19.1	335.5 (AFT)	245	.007394

NOTE: PSA ~ NORMAL MODE

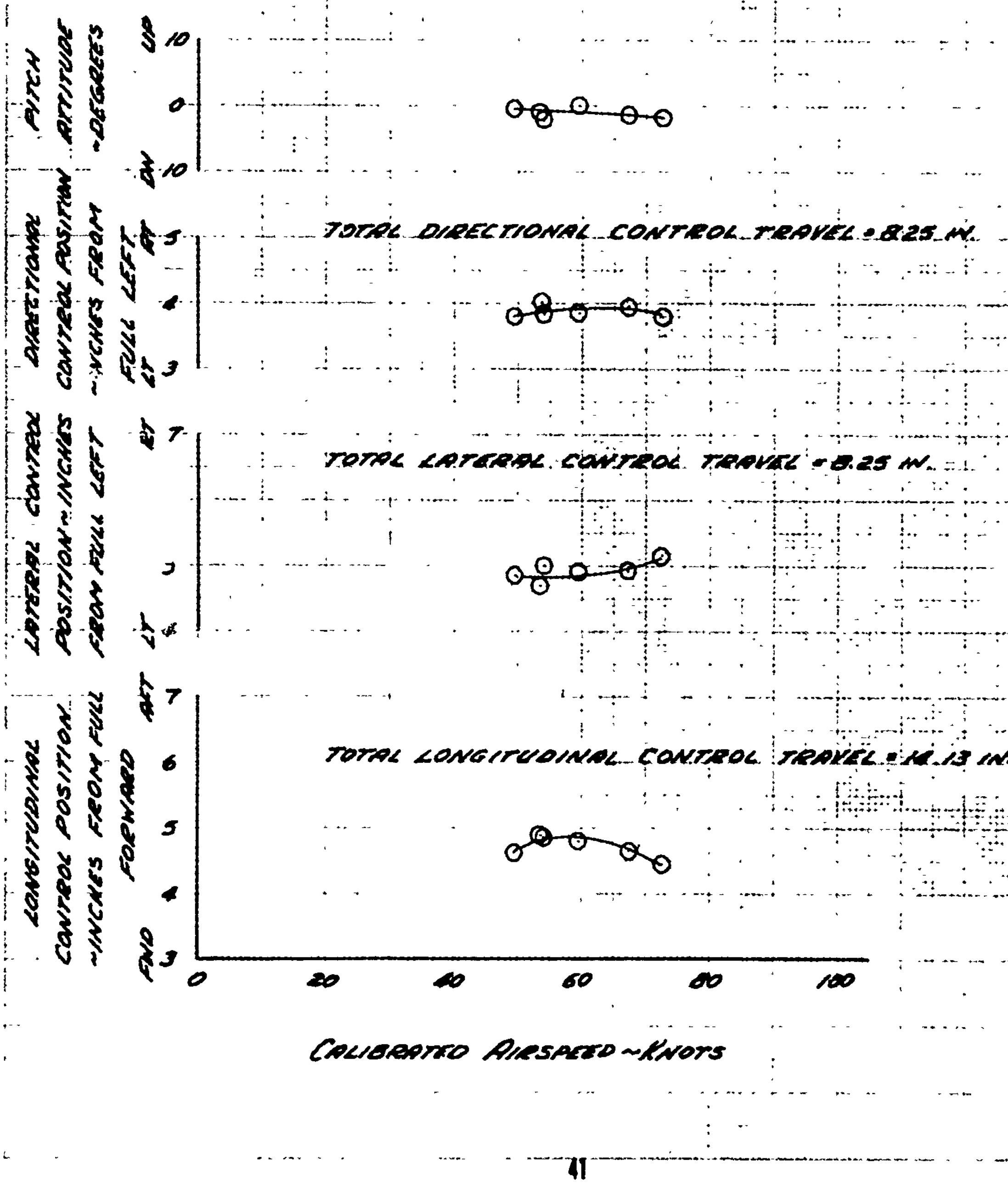


FIGURE 5
TRIM CONTROL POSITIONS
IN
SIDEWARD FLIGHT

CH-47C USA S/N 68-15859

AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T
46,370	1530	7.3	335.2 (AFT)	245	.006092

NOTE: PSA ~ AUTO MODE

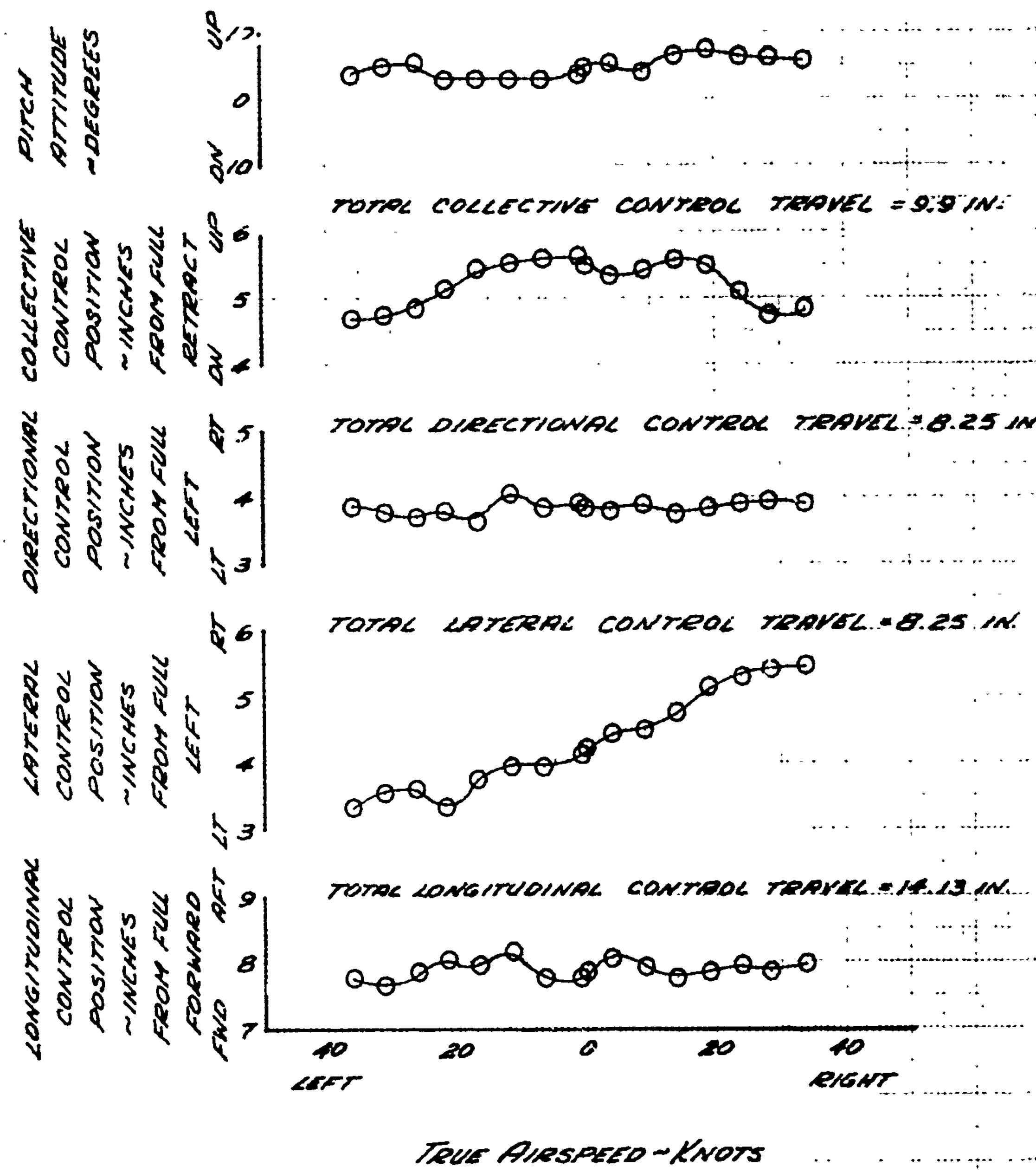


FIGURE 6
TRIM CONTROL POSITIONS
IN
REARWARD AND FORWARD FLIGHT
CH-47C USA S/N 68-15859

AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T
45,390	1420	6.5	335.6 (AFT)	245	.005943

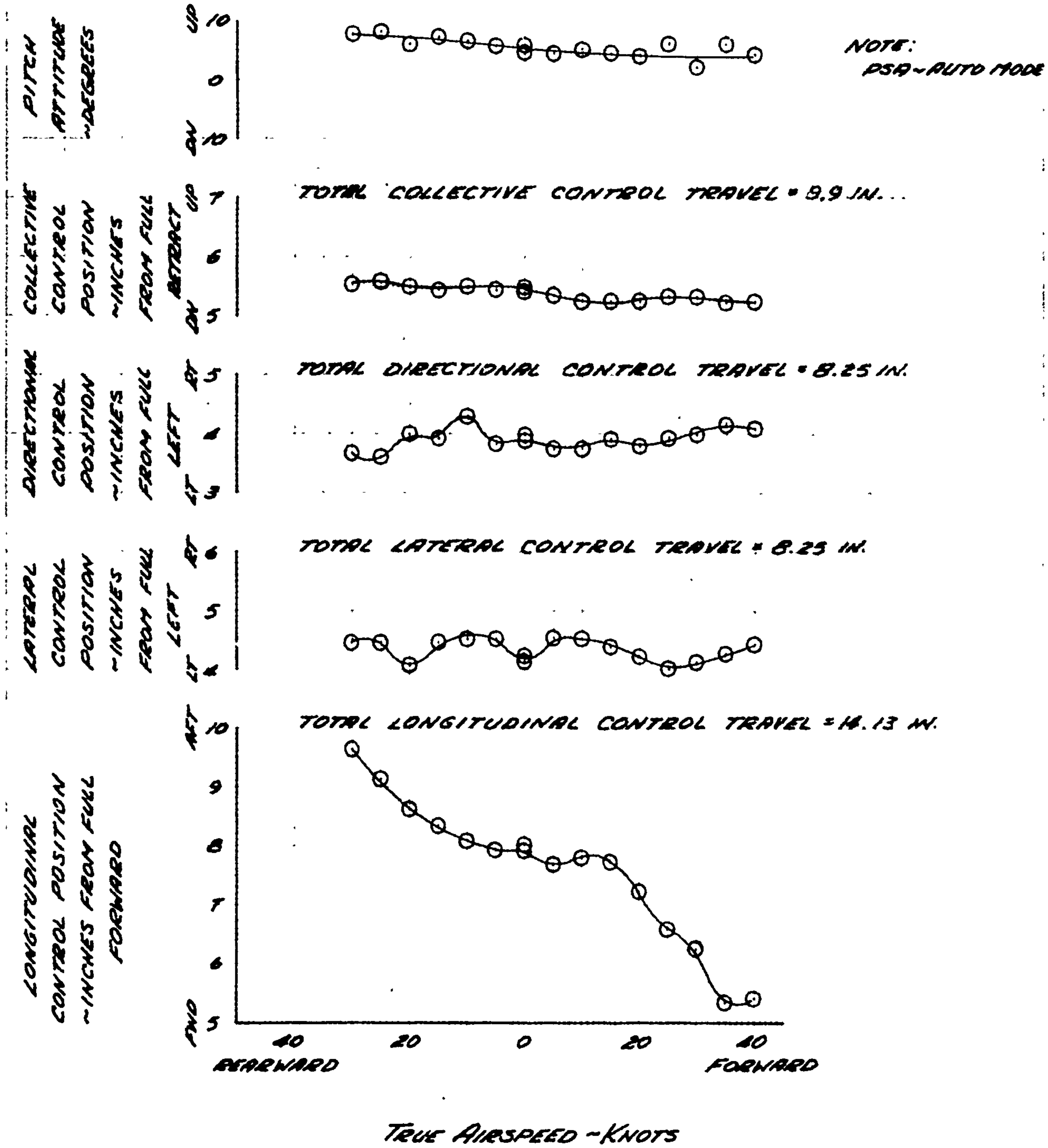


FIGURE 7
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	33,650	5060	25.5	337.4 (AFT)	235	.005340	78
△	LEVEL	33,690	5500	26.5	337.5 (AFT)	235	.005418	131
□	LEVEL	33,720	5310	27.0	337.5 (AFT)	235	.005392	145

NOTE: 1. PSA - NORMAL MODE
2. SHADED SYMBOLS DENOTE TRIM POINT

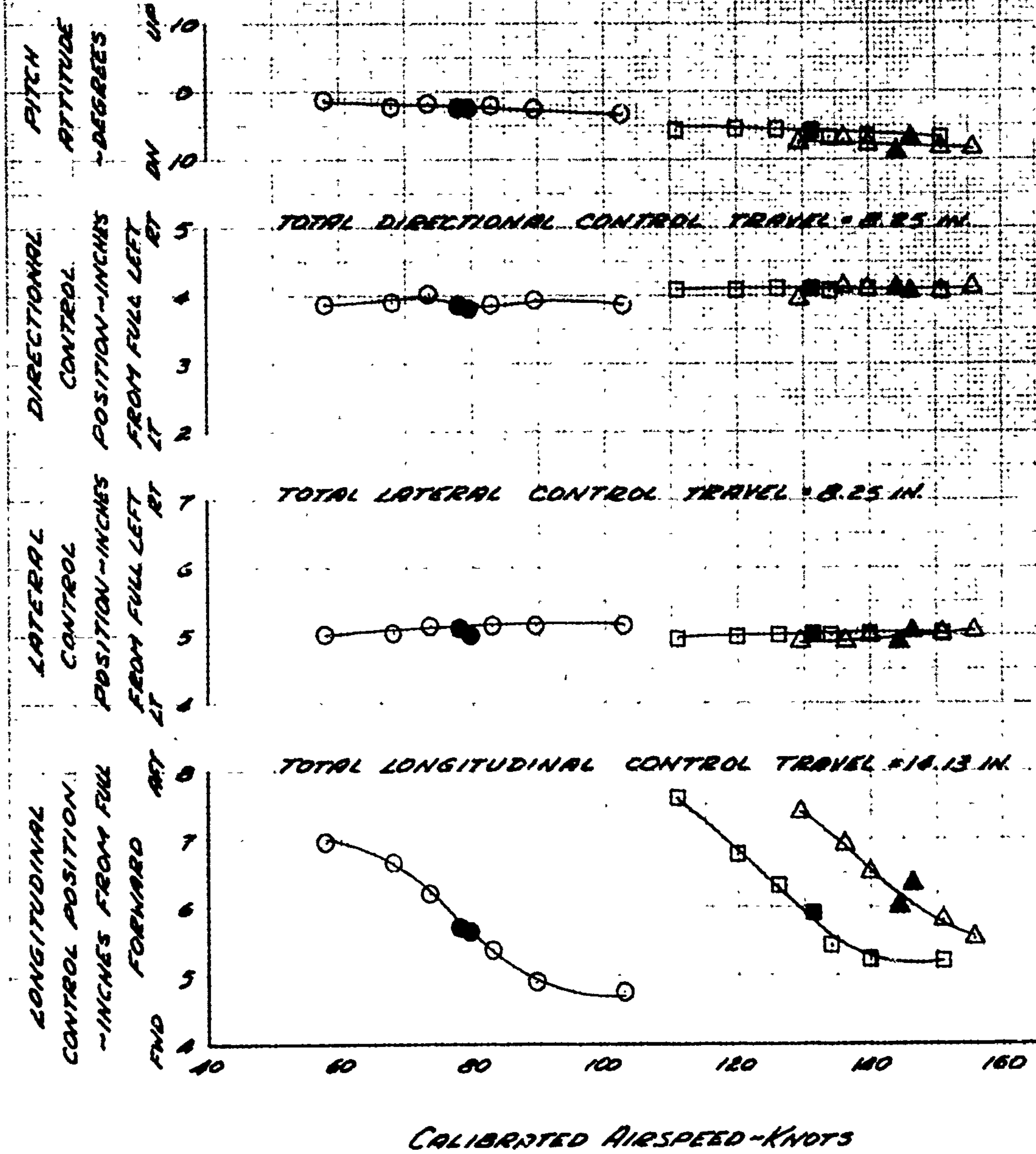


FIGURE 8
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	45,450	4910	8.5	335.6 (AFT)	245	.006607	81
□	LEVEL	44,950	5340	7.0	335.8 (AFT)	245	.006629	102

NOTE: 1. PSA ~ NORMAL MODE
2. SHADED SYMBOLS DENOTE TRIM POINT

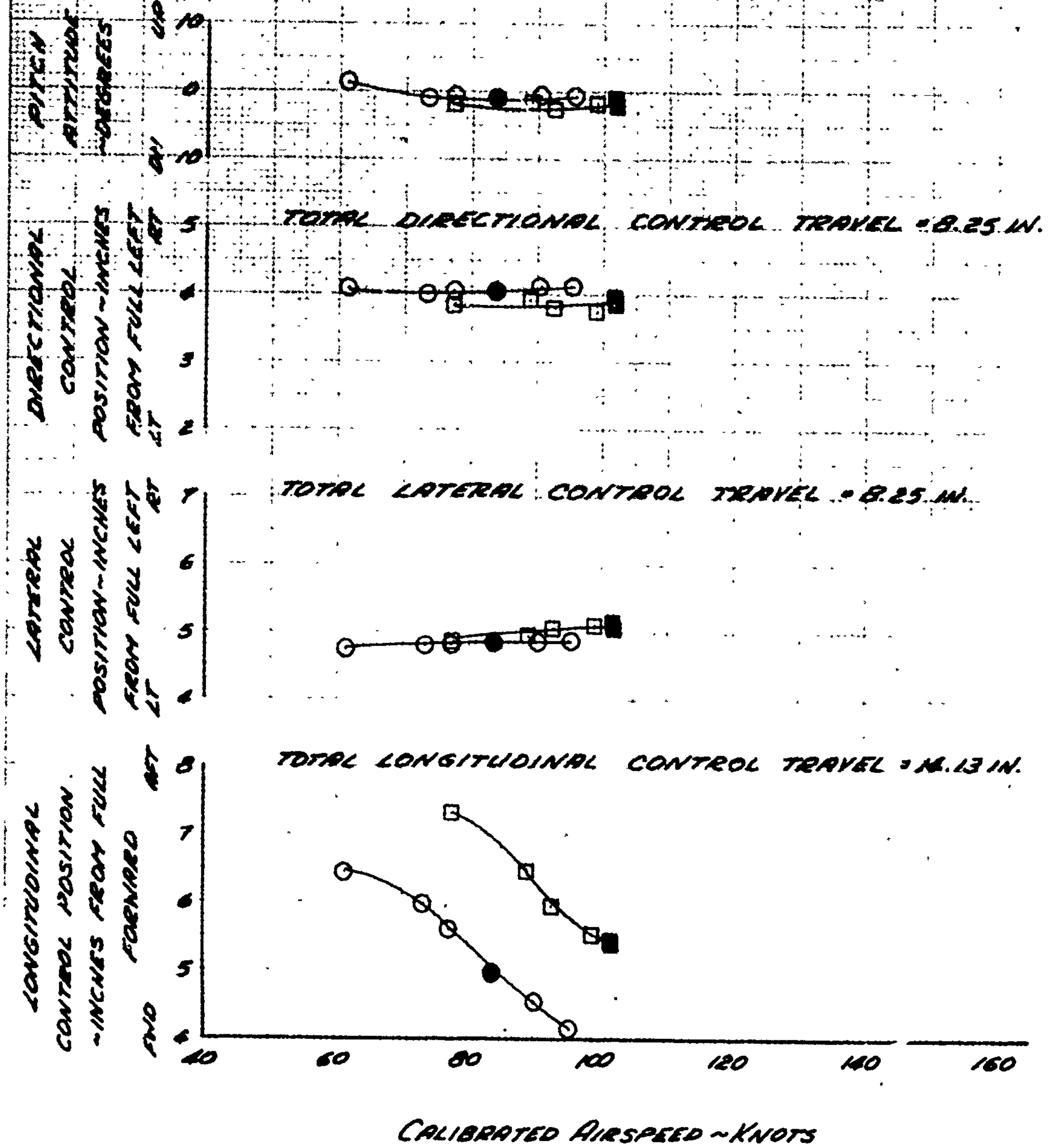


FIGURE 9
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○ (flagged)	CLIMB	46,050	5300	15.0	335.3 (AFT)	245	.006773	79
○	CLIMB	45,510	4840	13.5	335.5 (AFT)	245	.006601	79
□ (flagged)	AUTO	46,050	5300	15.0	335.3 (AFT)	245	.006773	80
□	AUTO	44,920	5120	13.0	335.9 (AFT)	245	.006572	80

NOTE: 1. PSA ~ NORMAL MODE
2. FLAGGED SYMBOL DENOTES PSA ~ OFF
3. SHADED SYMBOL DENOTES TRIM POINT

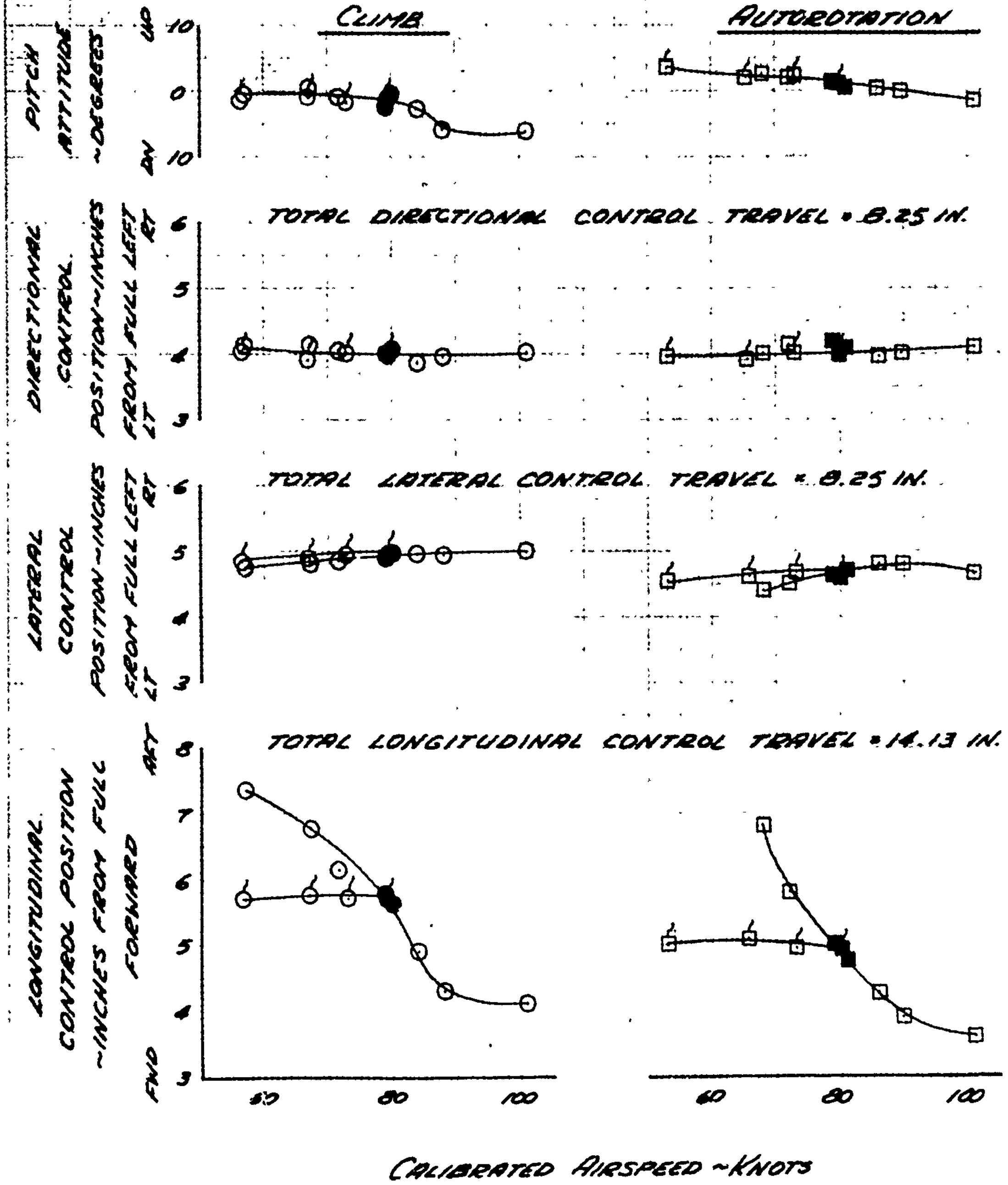


FIGURE 10

STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY

CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	45,030	7860	5.5	335.7 (AFT)	245	.007164	71
□	LEVEL	44,970	7640	11.0	335.7 (AFT)	245	.007105	72

NOTE: SHADED SYMBOLS DENOTE TRIM POINT

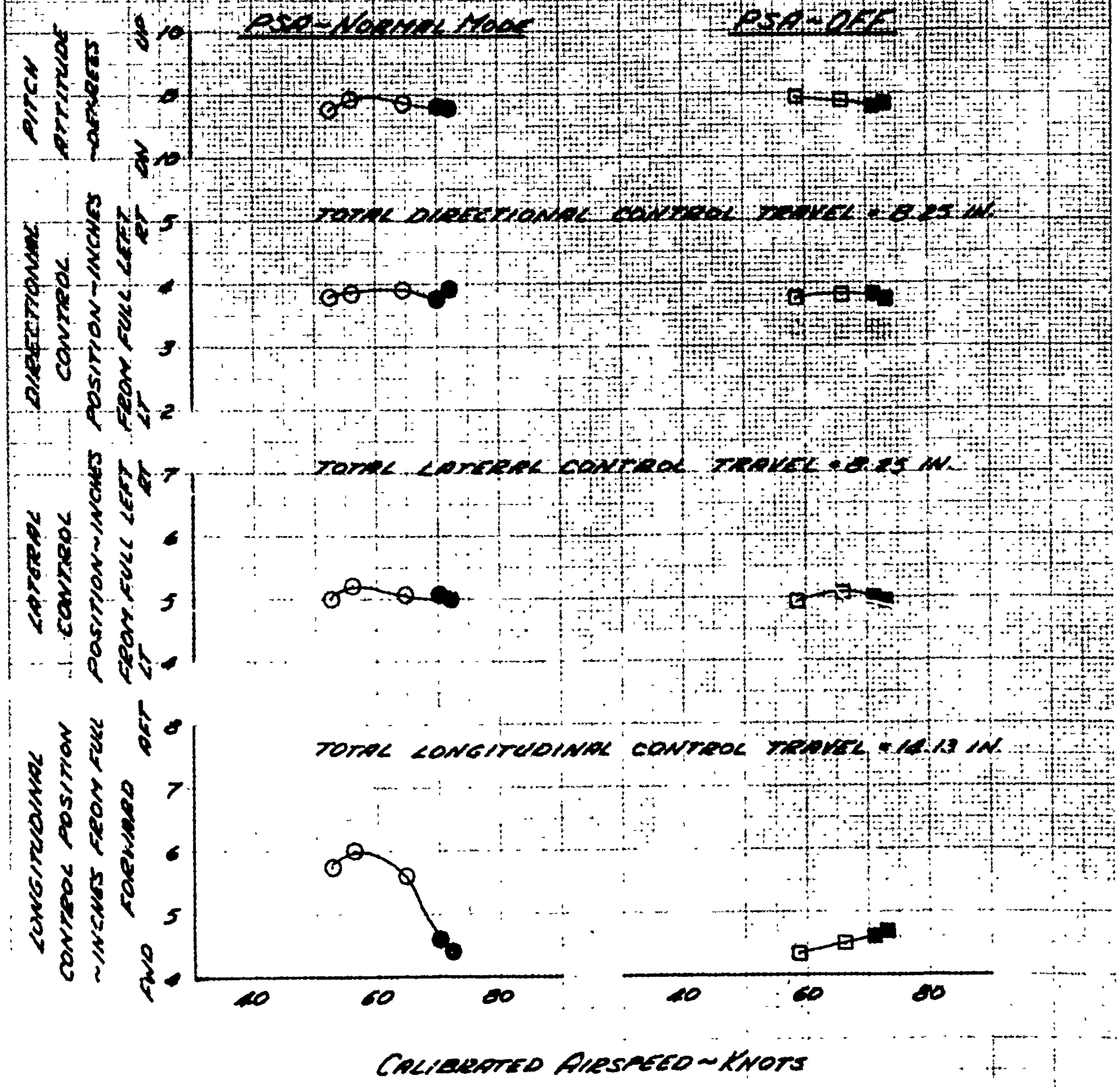


FIGURE 11
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	32,960	5040	25.0	338.0 (AFT)	235	.005227	80
□	LEVEL	33,110	5420	26.5	337.4 (AFT)	235	.005313	129
△	LEVEL	33,070	5500	26.5	337.7 (AFT)	235	.005318	144

NOTE: 1. PSA ~ OFF
2. SHADED SYMBOL DENOTES TRIM POINT

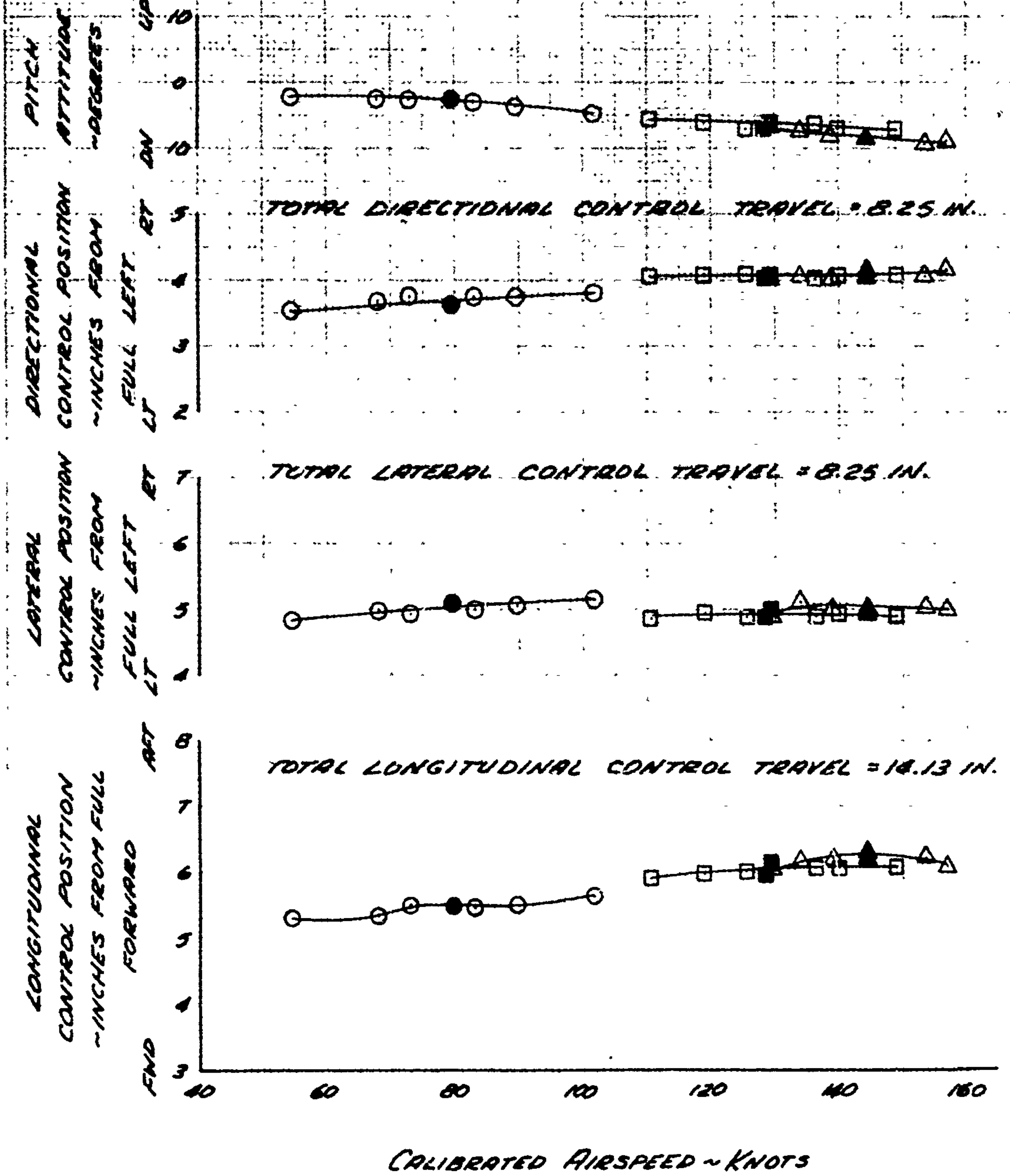
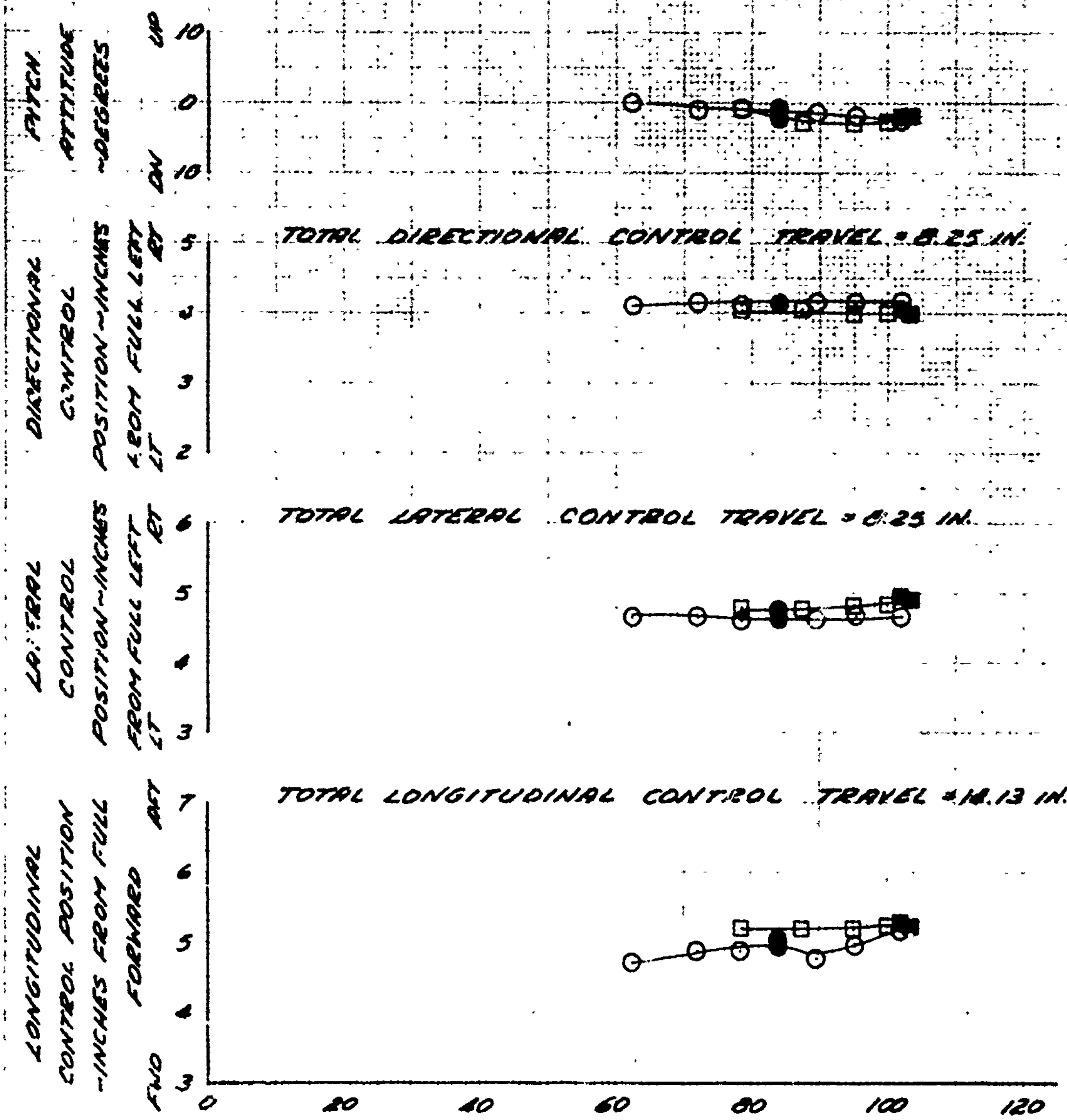


FIGURE 12
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	46,480	4630	8.5	335.2 (AFT)	245	.006700	84
□	LEVEL	45,920	5090	8.5	335.4 (AFT)	245	.006712	103

NOTE: 1. PSA-OFF
2. SHADED SYMBOLS DENOTE TRIM POINT



CALIBRATED AIRSPEED ~ KNOTS

FIGURE 13
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	44,730	4720	19.5	336.0 (AFT)	245	.006465	84
□	LEVEL	44,360	5200	19.0	336.2 (AFT)	245	.006505	103

NOTE: 1. PSA ~ OFF
2. 10,000 LB SLING LOAD
3. SHADED SYMBOLS DENOTE TRIM POINTS

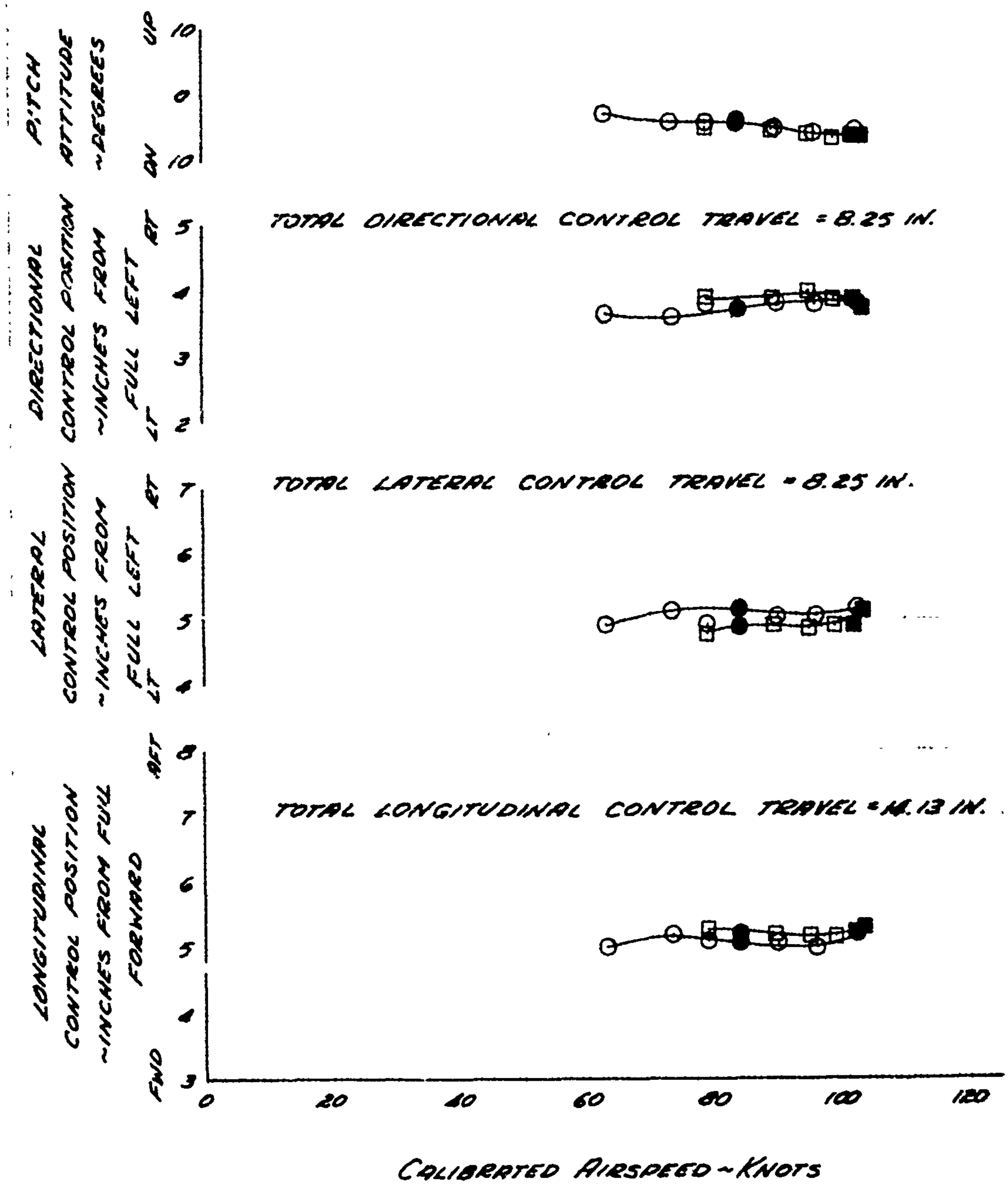


FIGURE 14
STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY
CH-47C USA S/N 68-15859

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C G LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
○	LEVEL	33,290	4750	26.5	337.3 (AFT)	235	.005234	79
□	LEVEL	33,370	5860	26.5	337.1 (AFT)	235	.005428	131
△	LEVEL	33,390	5440	26.5	337.1 (AFT)	235	.005360	145

NOTE: 1. PSA ~ AUTO MODE
2. SHADED SYMBOLS DENOTE TRIM POINT

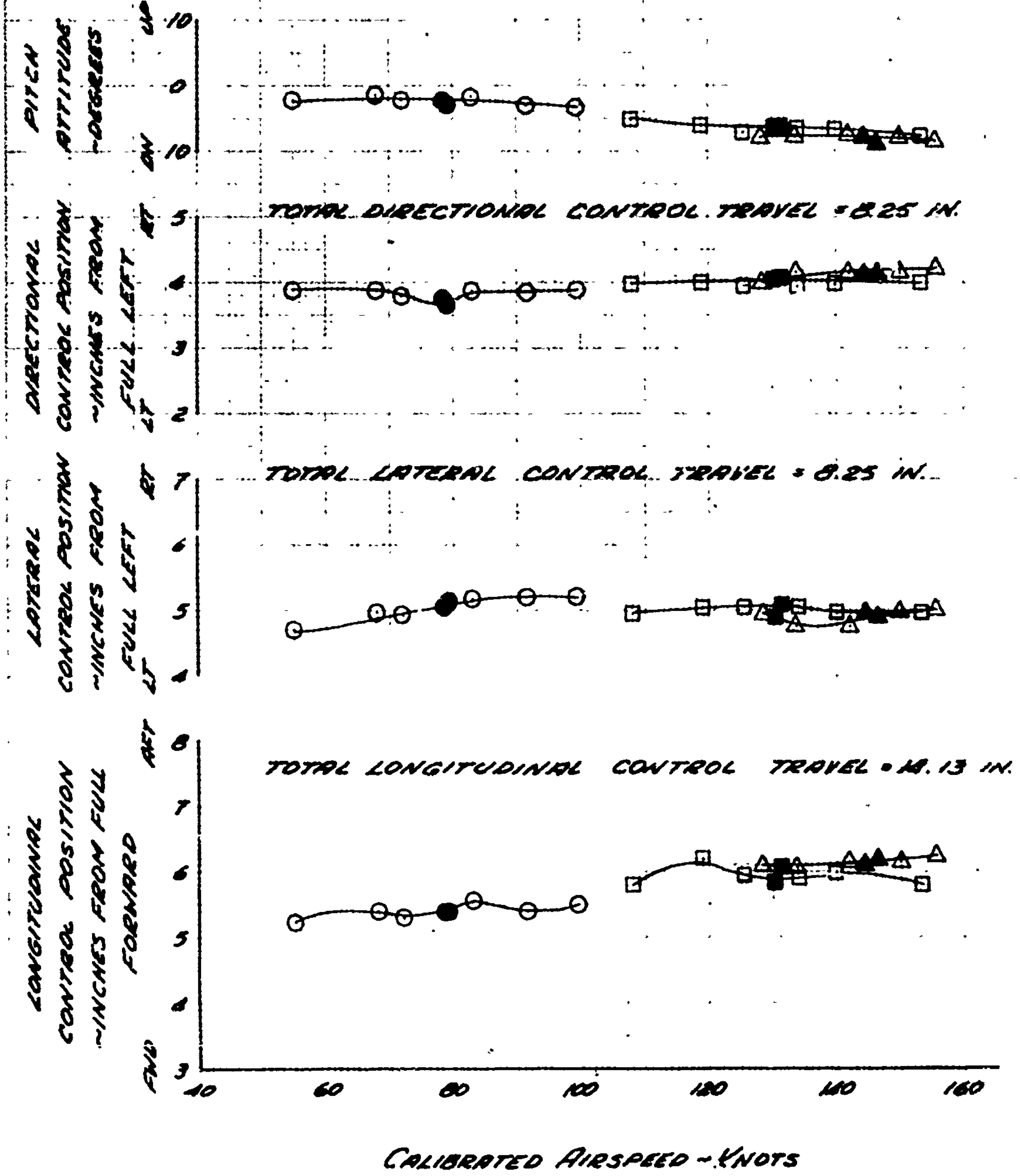


FIGURE 15
STATIC LATERAL DIRECTIONAL STABILITY
CH-47C USA S/N 68-15859

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
LEVEL	46,210	5100	24.0	335.4 (AFT)	245	.006756	82

NOTE: PSA ~ NORMAL MODE

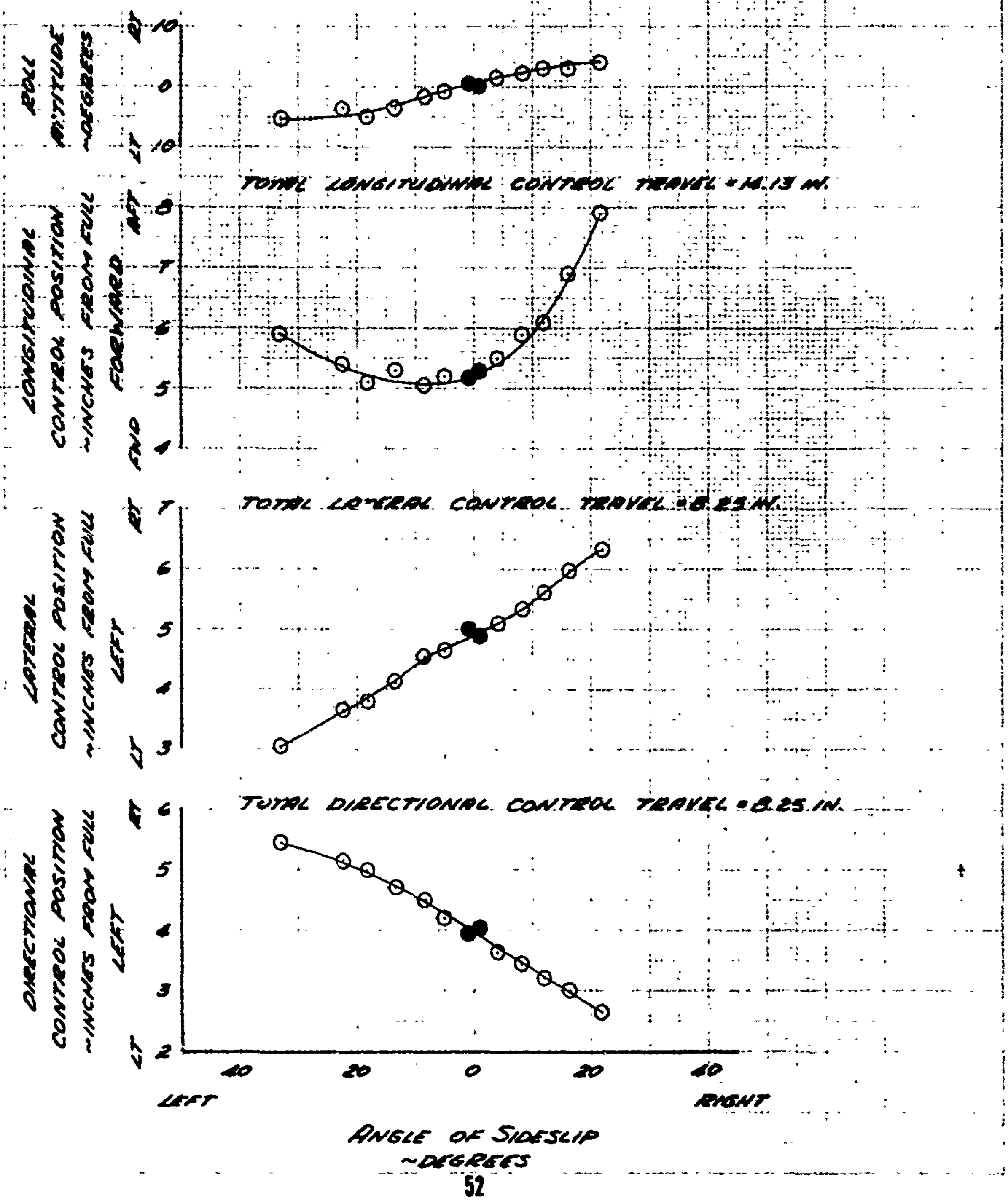


FIGURE 16

STATIC LATERAL DIRECTIONAL STABILITY

CH-47C USA S/N 68-15859

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
LEVEL	45,460	4730	24.5	335.7 (AFT)	245	.006571	104

NOTE: PSA ~ NORMAL MODE

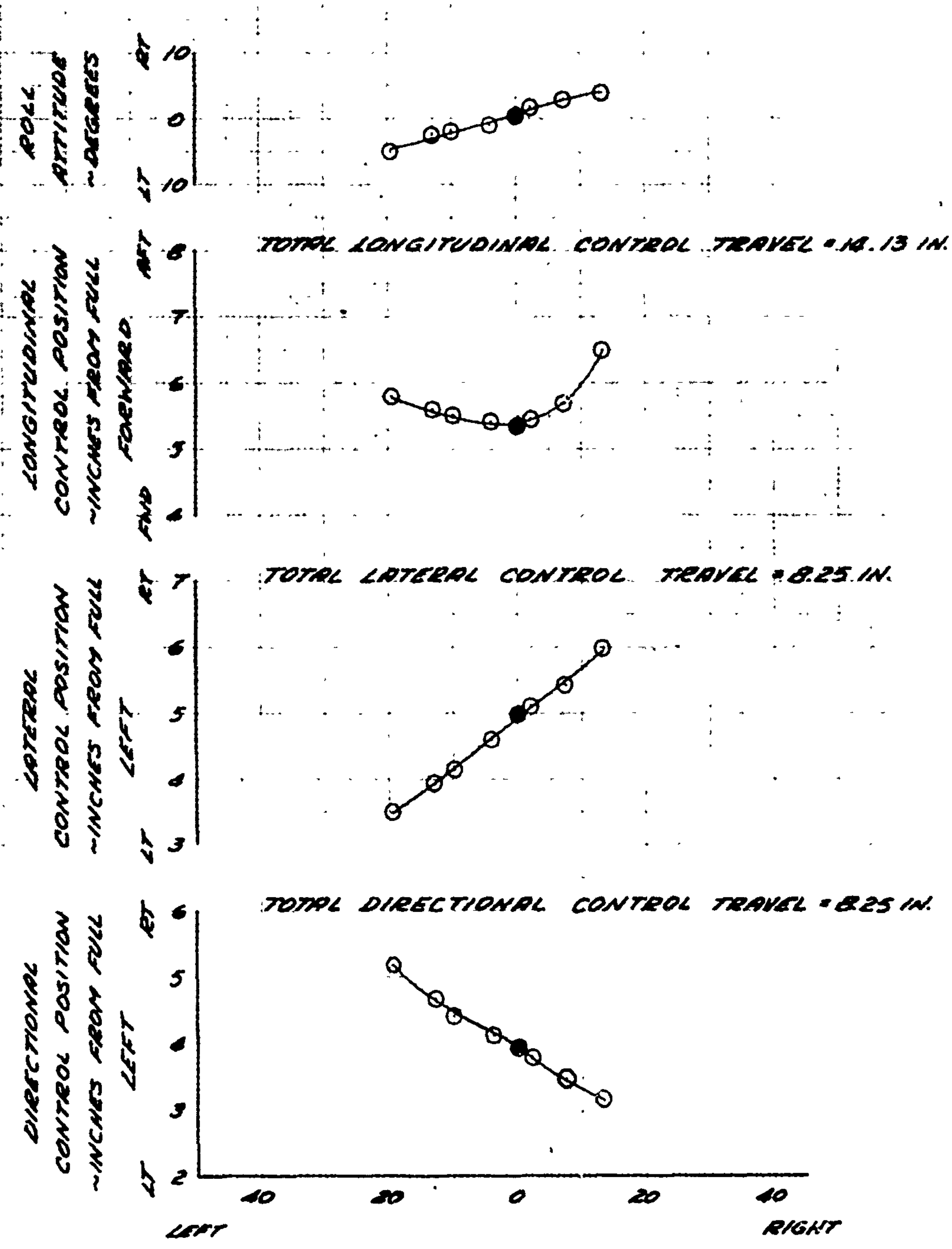


FIGURE 17
STATIC LATERAL DIRECTIONAL STABILITY
CH-47C USA S/N 68-15859

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
LEVEL	44610	4740	12.0	335.9 (AFT)	245	.006542	84

NOTE: PSA ~ OFF

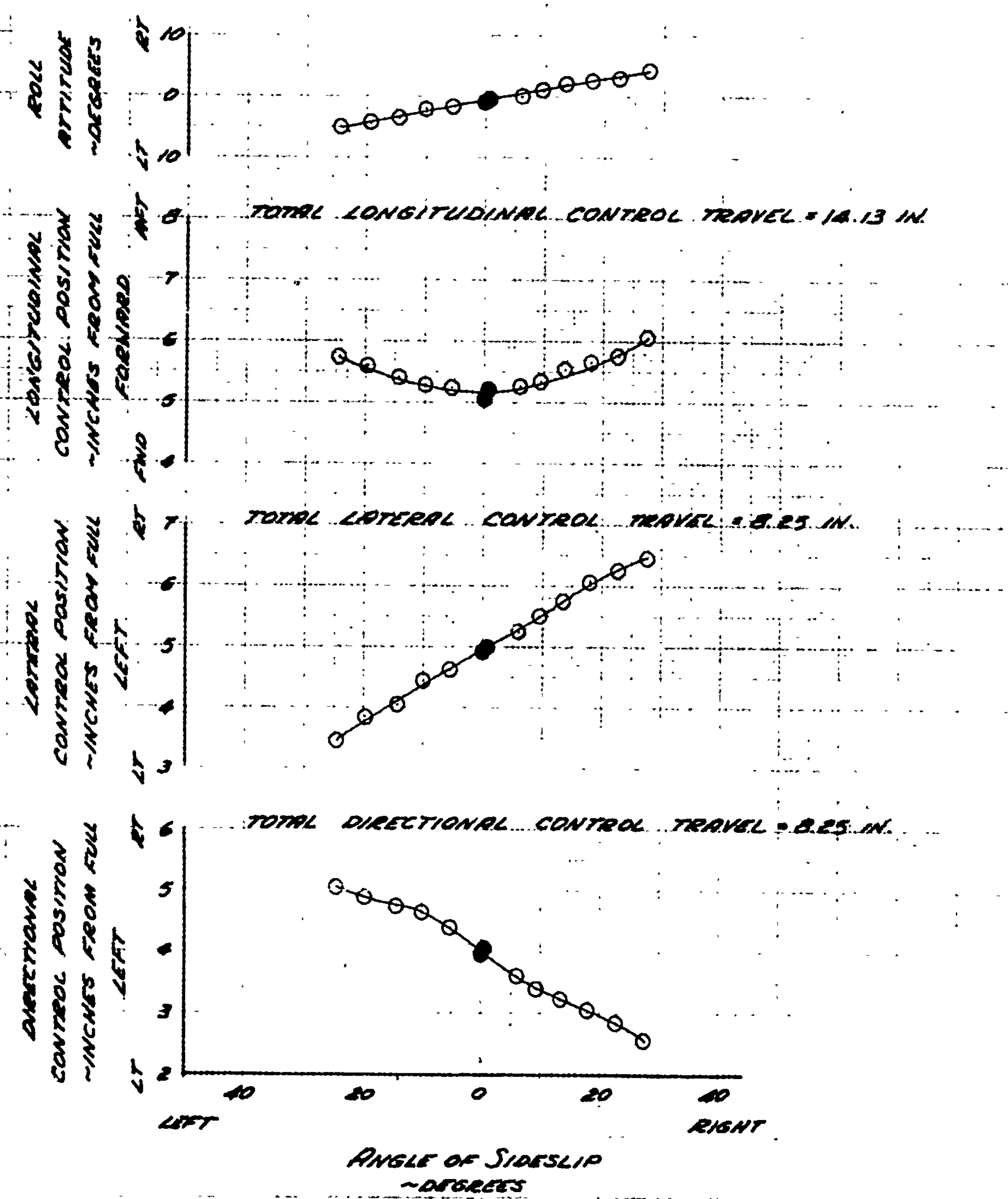


FIGURE 18

STATIC LATERAL DIRECTIONAL STABILITY

CH-47C USA S/N 68-15859

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
LEVEL	45,950	4800	13.5	335.4 (AFT)	245	.006657	103

NOTE: PSA ~ OFF

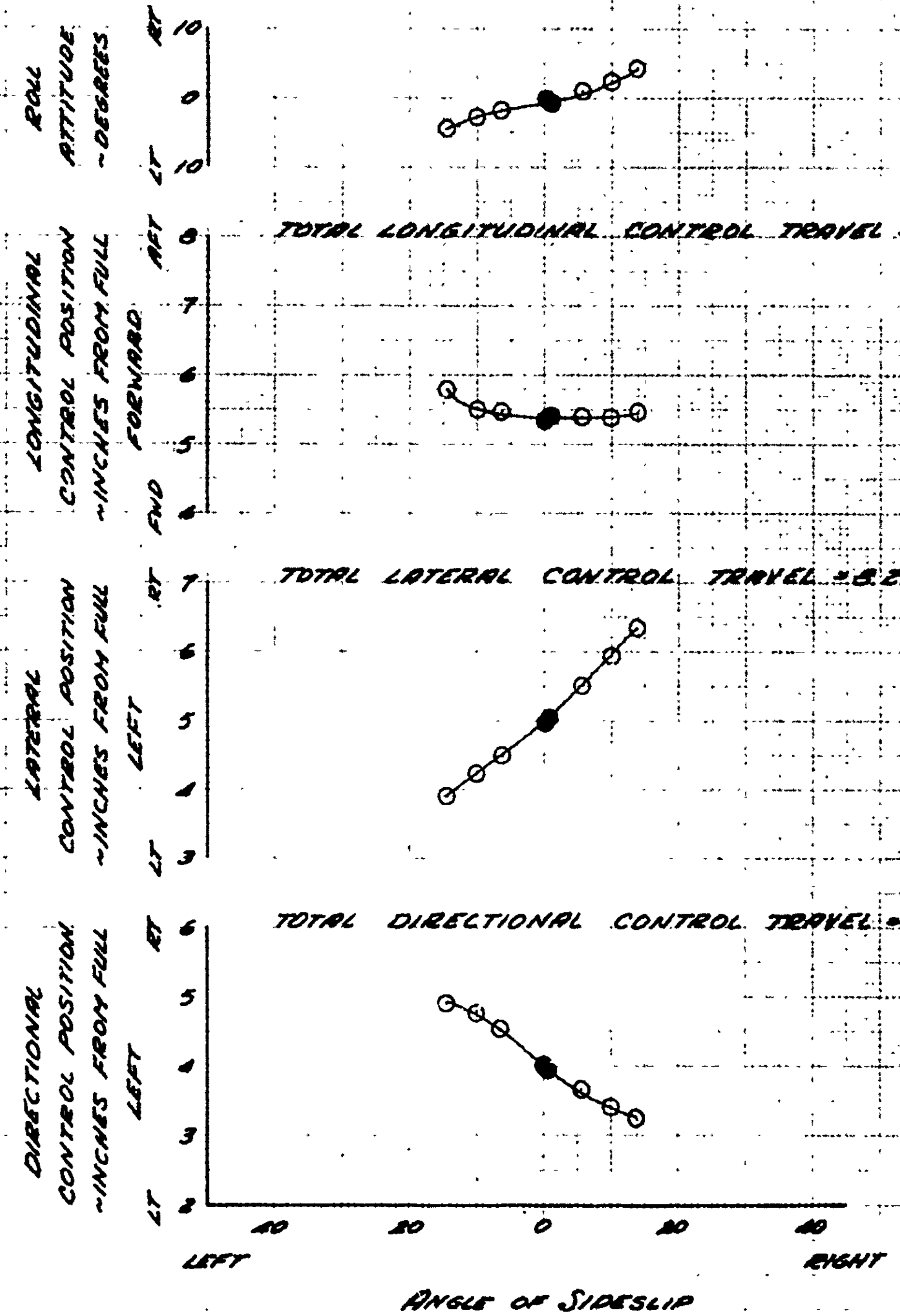


Figure 19

Static Lateral Directional Stability
CH-47C USA S/N 68-15859

Symbol	Flight Condition	Avg Gross Weight (LB)	Avg Density Altitude (FT)	Avg OAT (°C)	Avg CG Location (IN.)	Avg Rotor Speed (RPM)	Avg C_T	Trim A/S (KCAS)
○	Climb	46,490	4340	8.0	335.2 (AFT)	245	.006643	79
□	Auto	45,370	4220	7.9	335.6 (AFT)	245	.006459	80

NOTE: PSA ~ NORMAL MODE

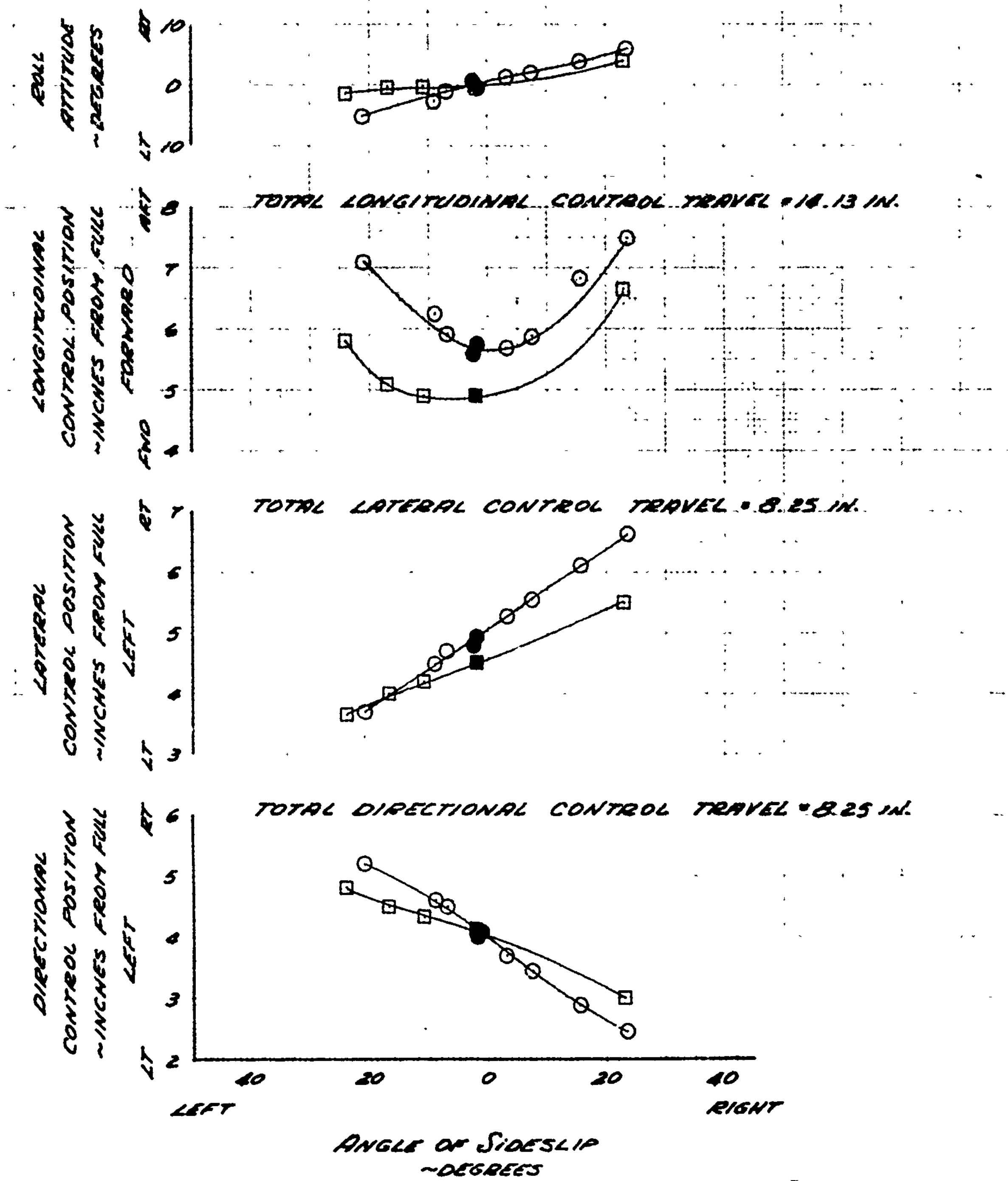


FIGURE 20
STATIC LATERAL DIRECTIONAL STABILITY
CH-47C USA S/N 68-15859

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
LEVEL	44,030	4770	20.5	335.8 (AFT)	245	.006372	65

NOTE: 1. PSA ~ NORMAL MODE
2. 10,000 LB SLING LOAD

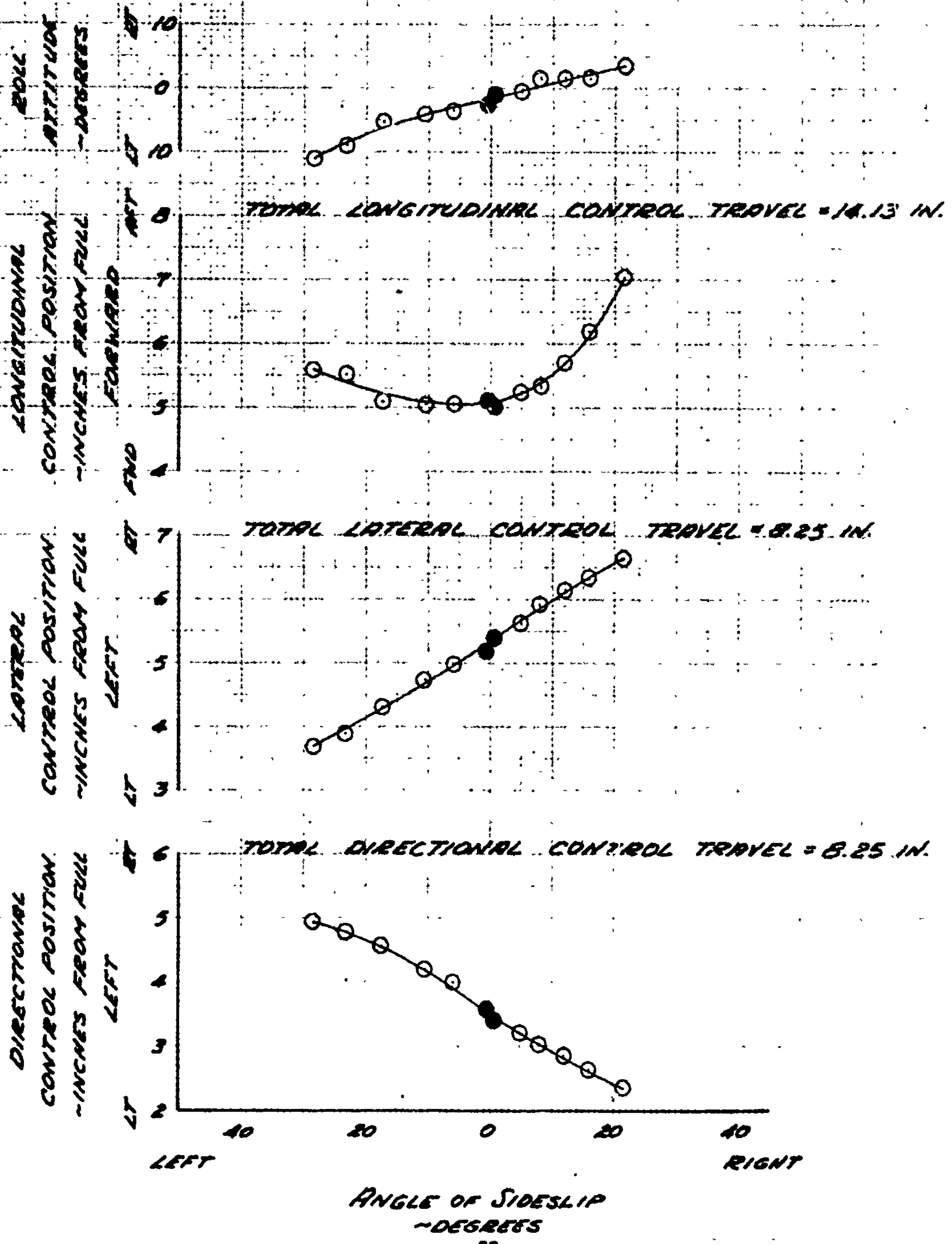


FIGURE 21
STATIC LATERAL DIRECTIONAL STABILITY
CH-47C USA S/N 68-15859

FLIGHT CONDITION	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN)	AVG ROTOR SPEED (RPM)	AVG C_T	TRIM A/S (KCAS)
LEVEL	45,580	5300	23.5	335.2 (AFT)	245	.006696	101

NOTE: 1. PSA ~ NORMAL MODE
2. 10,000 LB SLING LOAD

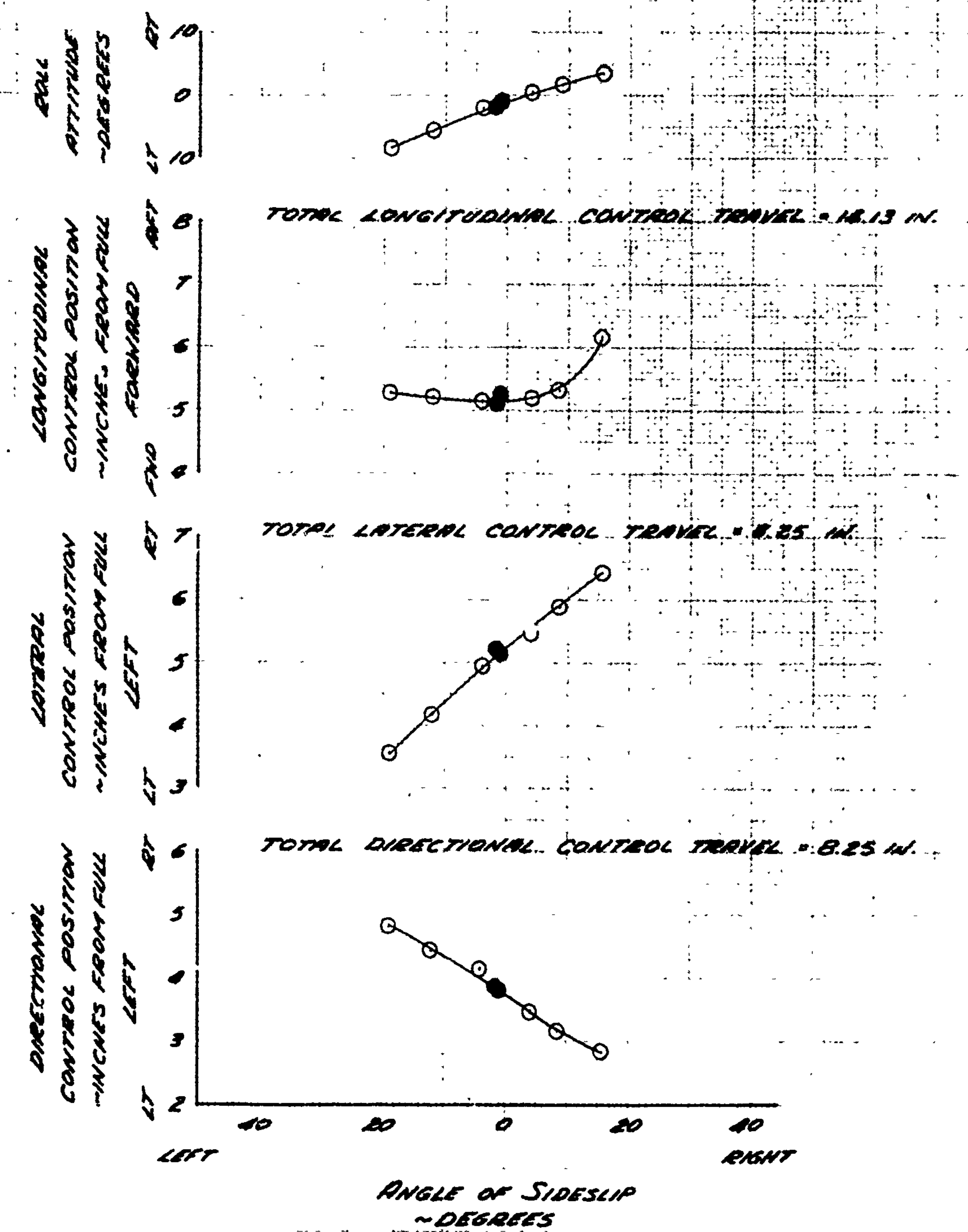


FIGURE 22

AIRCRAFT RESPONSE FOLLOWING AN AFT LONGITUDINAL PULSE

CH-47C USA S/N 68-15839

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
44,170	4770	26.0	336.8 (AFT)	243	0.006387	101

NOTES: 1. PSA – OFF

2. PULSE INTRODUCED THROUGH SAS PULSER BOX

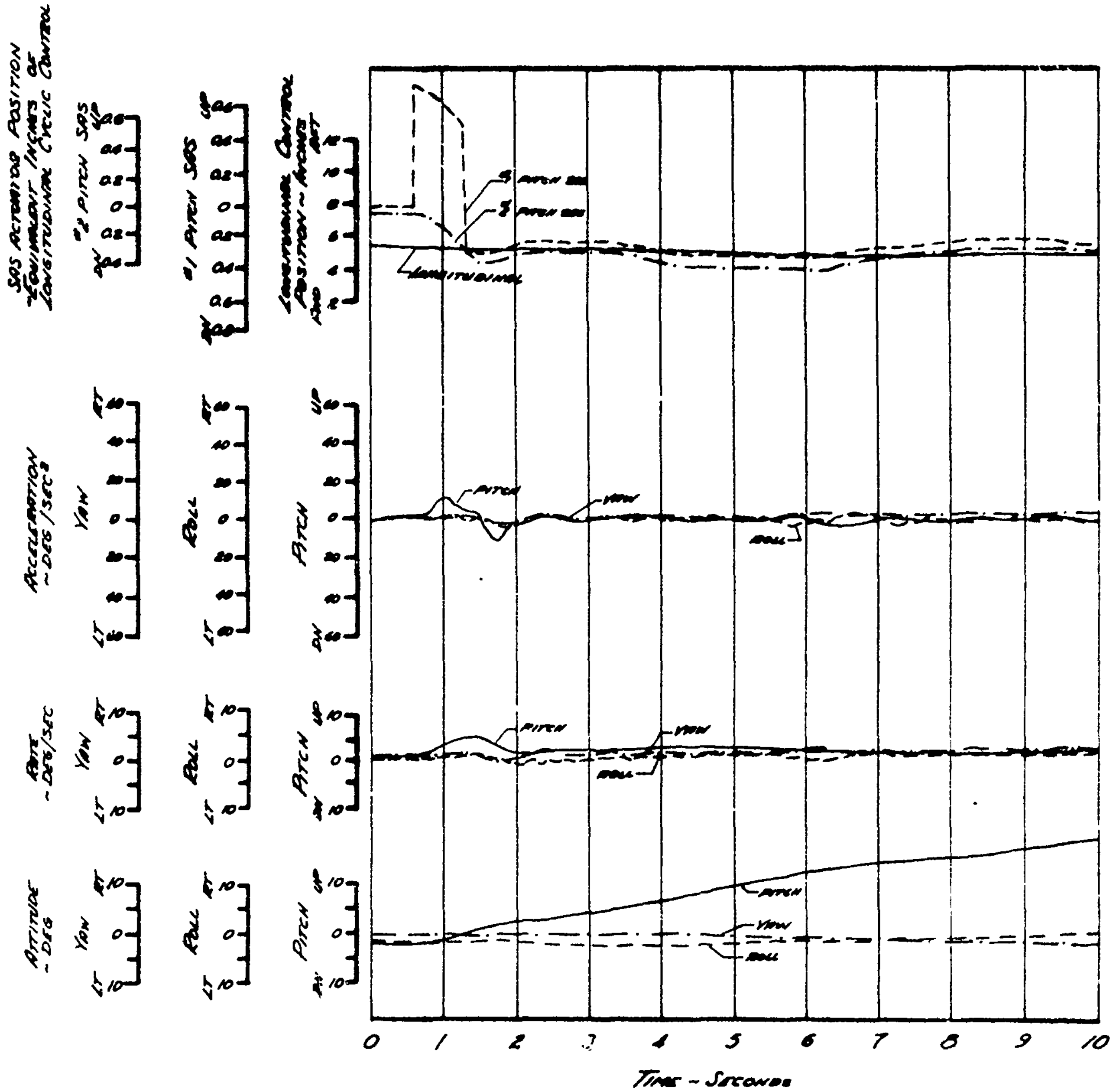


FIGURE 23

AIRCRAFT RESPONSE FOLLOWING A LEFT LATERAL PULSE

CH-47C USA S/N 68-15863

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT.)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
43680	2380	12.0	334.6 (AFT)	245	[illegible]	HOVER

NOTE: ASA ~ NORMAL MODE

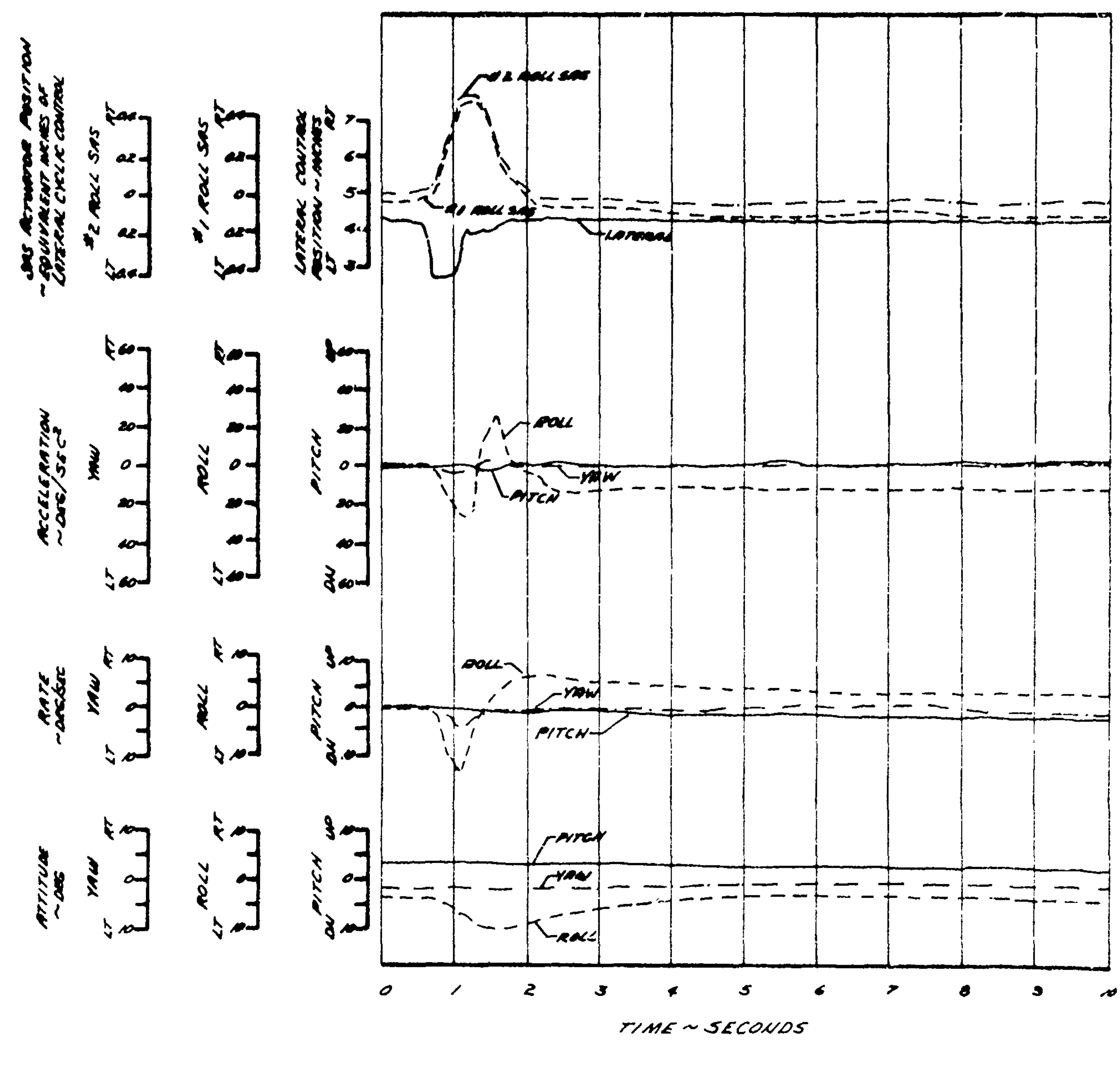


FIGURE 24

AIRCRAFT RESPONSE FOLLOWING A LEFT LATERAL PULSE

CH-47C USA S/N 68-15853

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
45,700	4570	16.0	335.5 (AFT)	245	0.006573	105

NOTE. ASA ~ NORMAL MODE

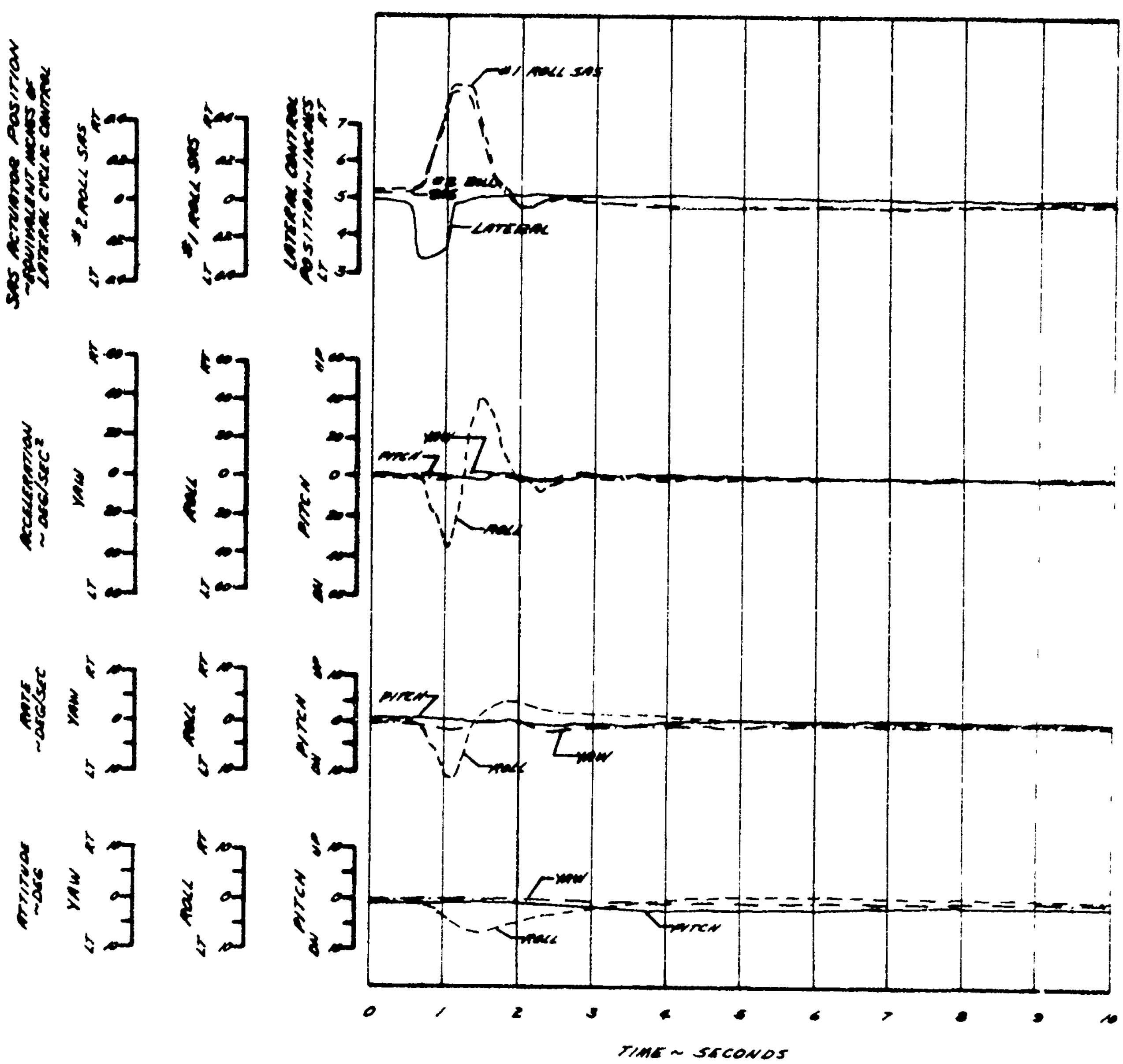


FIGURE 25

AIRCRAFT RESPONSE FOLLOWING A LEFT DIRECTIONAL PULSE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
44510	2820	[illegible]	336.0 (AFT)	243	[illegible]	HOVER

NOTE: PSA ~ NORMAL MODE

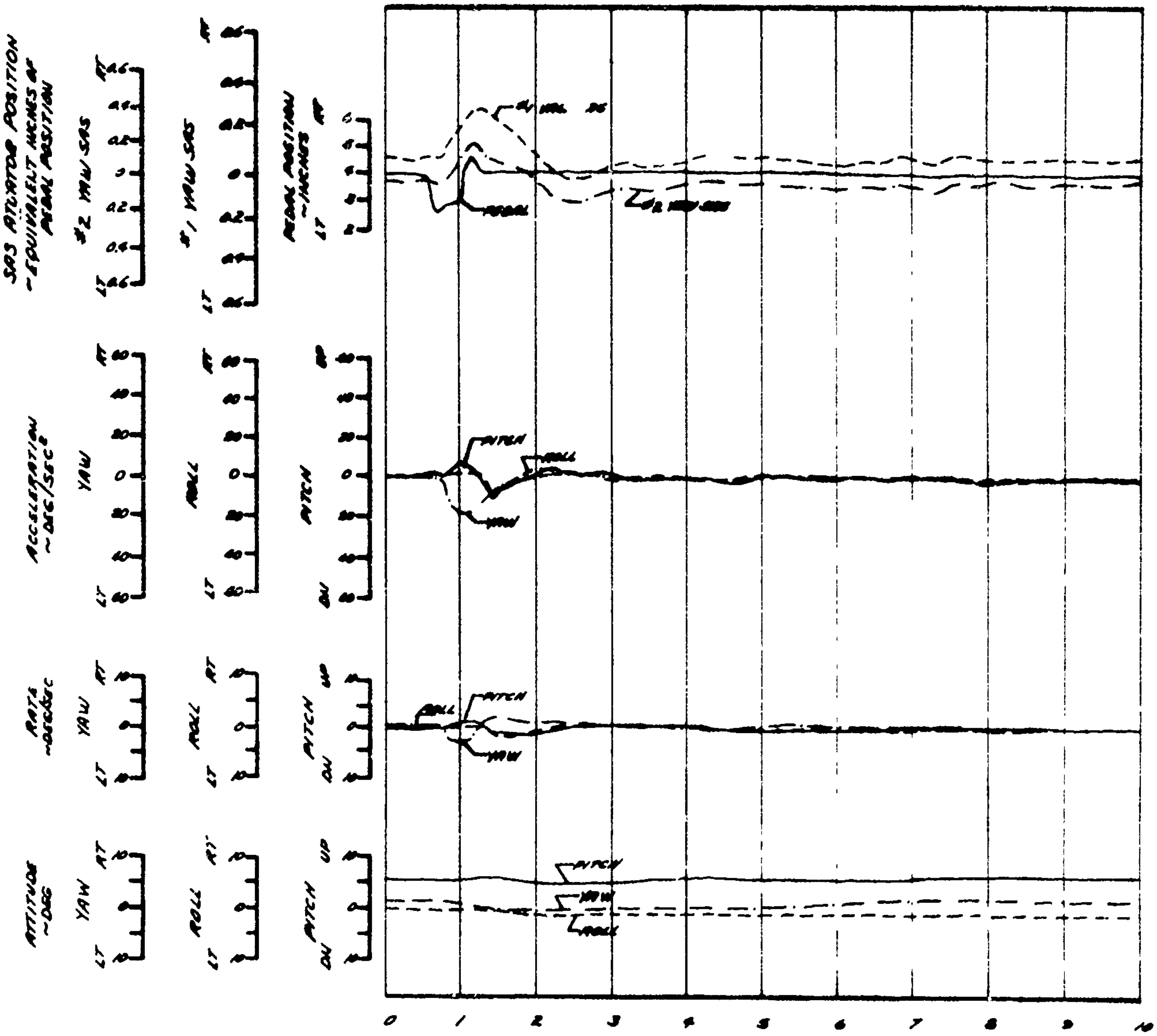


FIGURE 26

AIRCRAFT RESPONSE FOLLOWING A LEFT DIRECTIONAL PULSE

CH-47C USA S/N 68-15853

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
45520	4540	16.0	3356(AFT)	245	0.006593	106

NOTE: PSA ~ NORMAL MODE

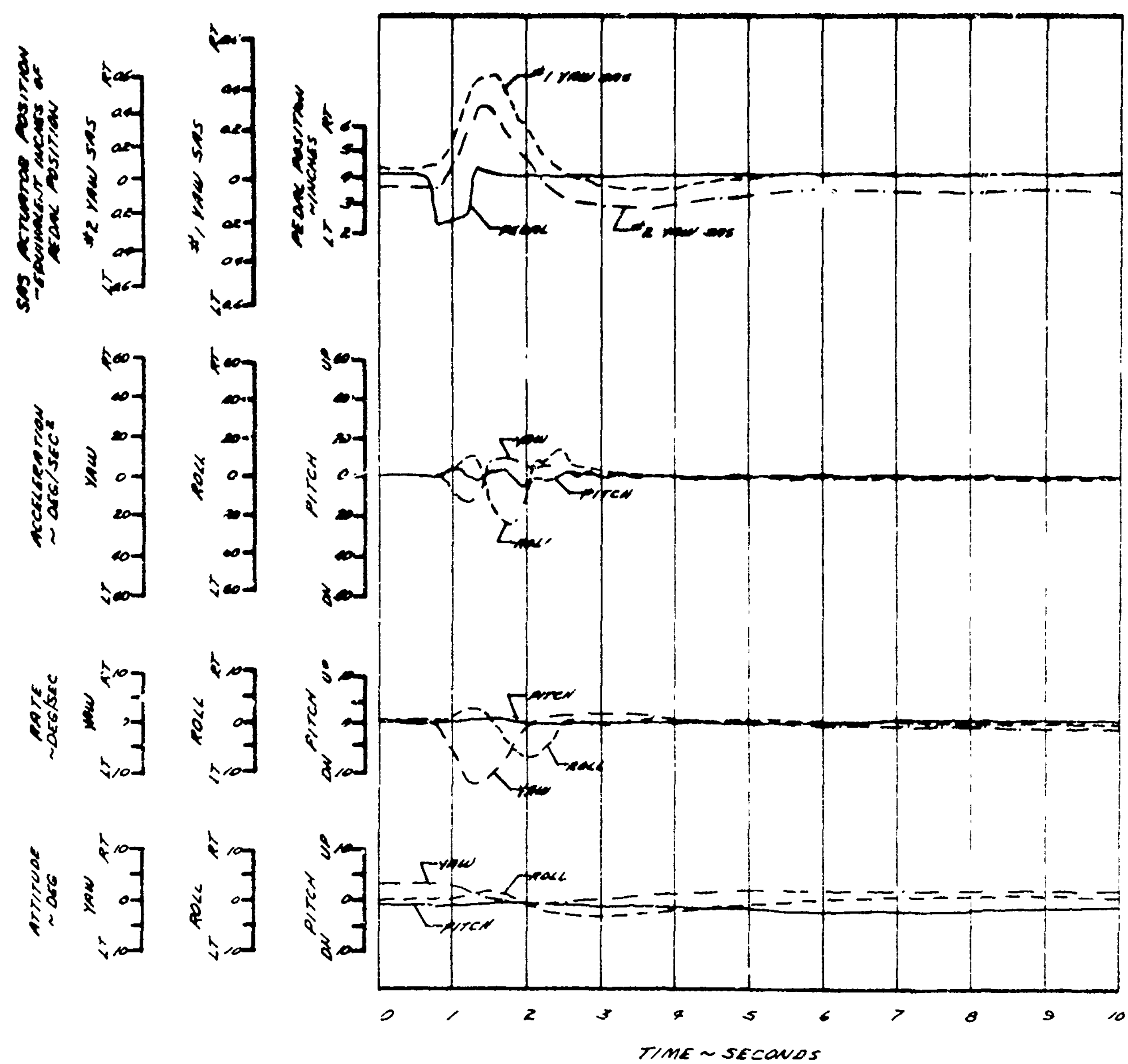


FIGURE 27

AIRCRAFT RESPONSE FOLLOWING AN AFT LONGITUDINAL PULSE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM [illegible] (KCAS)
44,210	4740	23.5	334.3(AFT)	245	0.[illegible]	105

NOTE: 1. PSA ~ NORMAL MODE
2. PULSE INTRODUCED THROUGH SAS PULSER BOX

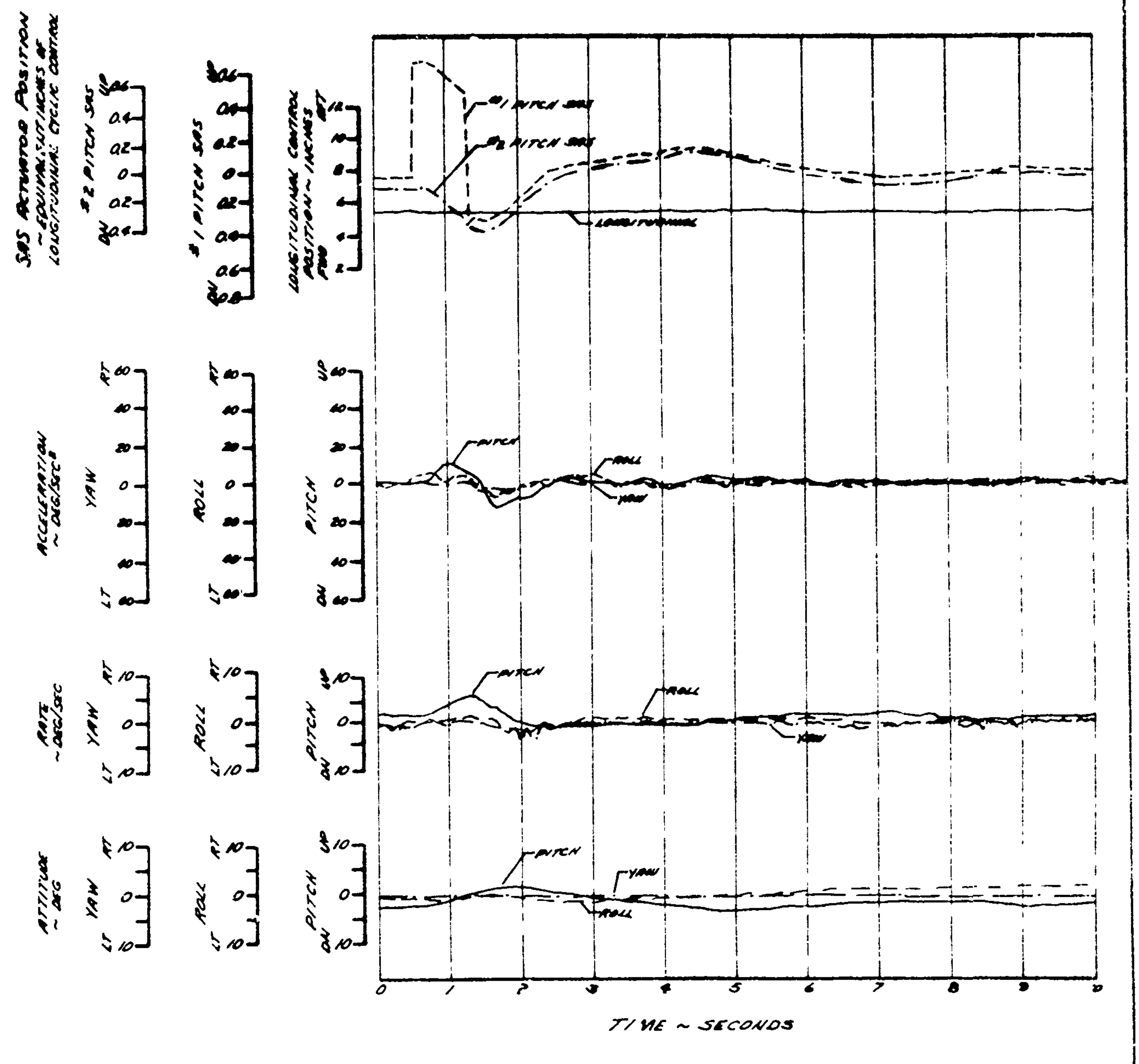


FIGURE 28

AIRCRAFT RESPONSE FOLLOWING AN AFT LONGITUDINAL PULSE

CH-47C USA S/N 68-15853

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
45,370	3530	21.6	339.7(AFT)	245	0.006337	HOVER

NOTES: 1. PSA ~ NORMAL MODE

2. PULSE INTRODUCED THROUGH SAS PULSER BOX

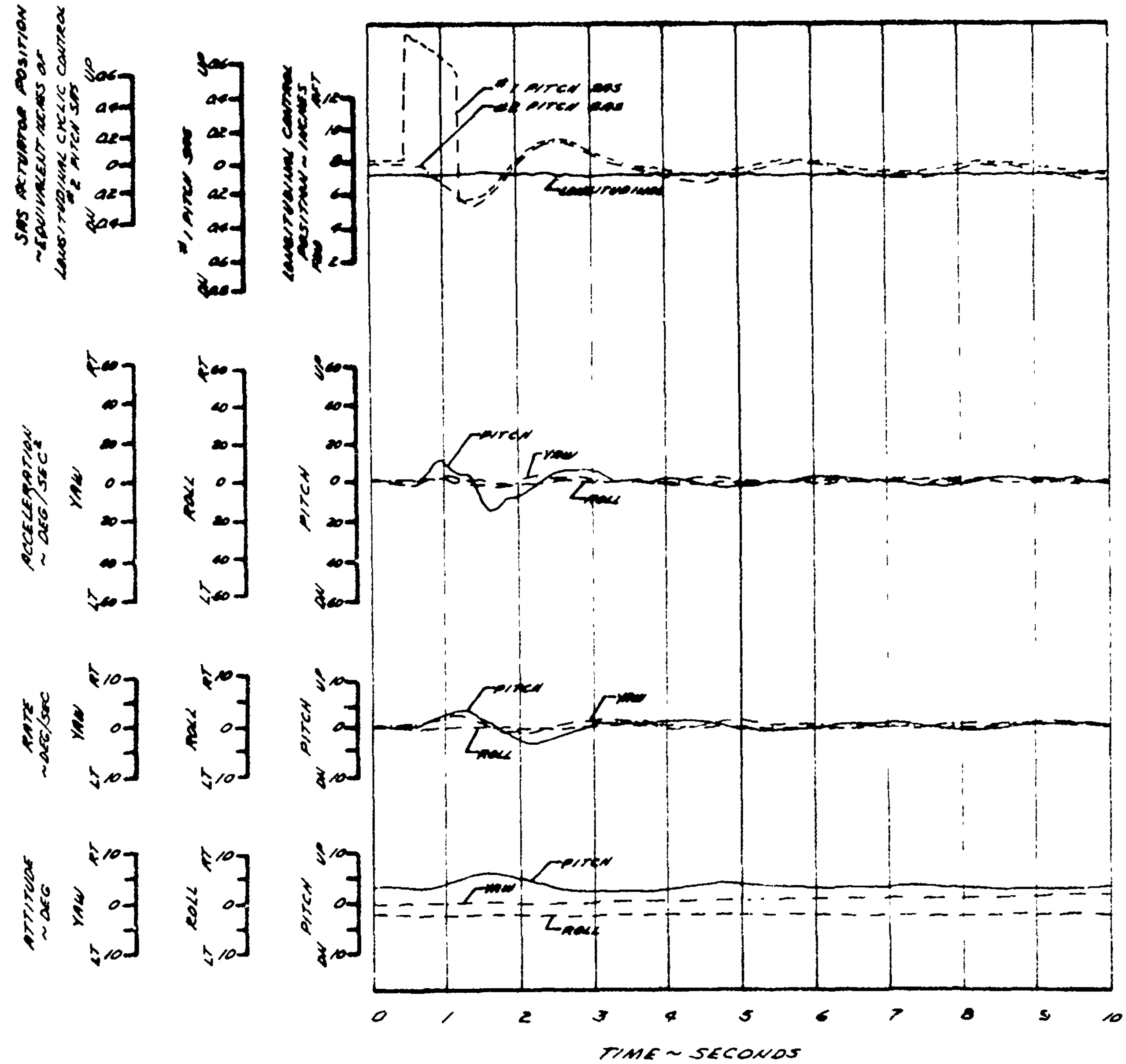


FIGURE 29

AIRCRAFT RESPONSE FOLLOWING A FORWARD LONGITUDINAL PULSE

CH-47C USA S/N 68-15853

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
45,450	3570	21.5	334.7(AFT)	245	0.006345	HOVER

NOTES: 1. PSA ~ NORMAL MODE

2. PULSE INTRODUCED THROUGH SAS PULSER BOX

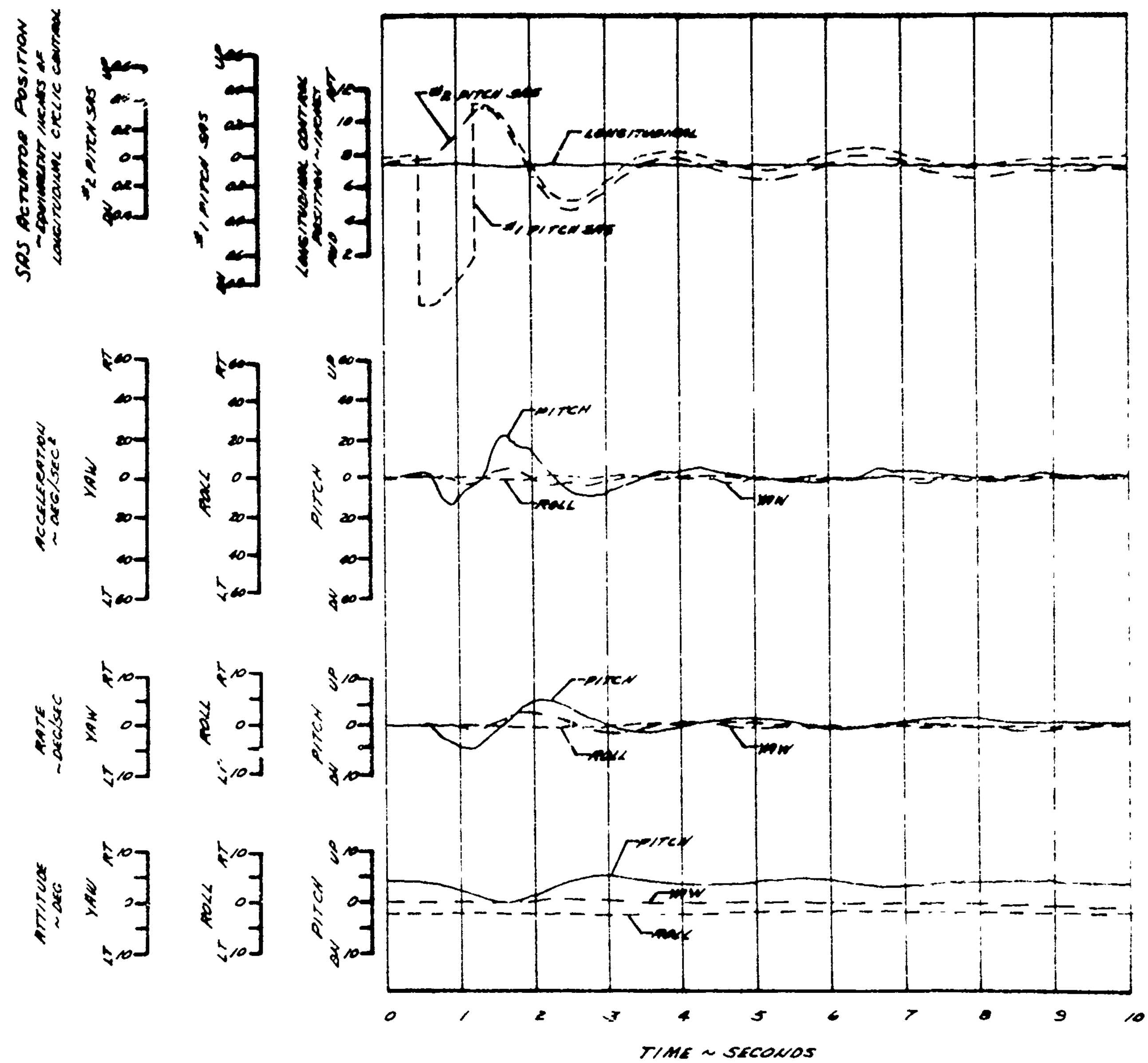


FIGURE 30

AIRCRAFT RESPONSE FOLLOWING AN AFT LONGITUDINAL PULSE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	ROTOR SPEED (RPM)	C_T	TRIM A/S (KCAS)
45340	3620	22.0	334.8 (AFT)	245	0.006339	HOVER

NOTES: 1. PSA ~ AUTO MODE

2. PULSE INTRODUCED THROUGH SAS PULSER BOX

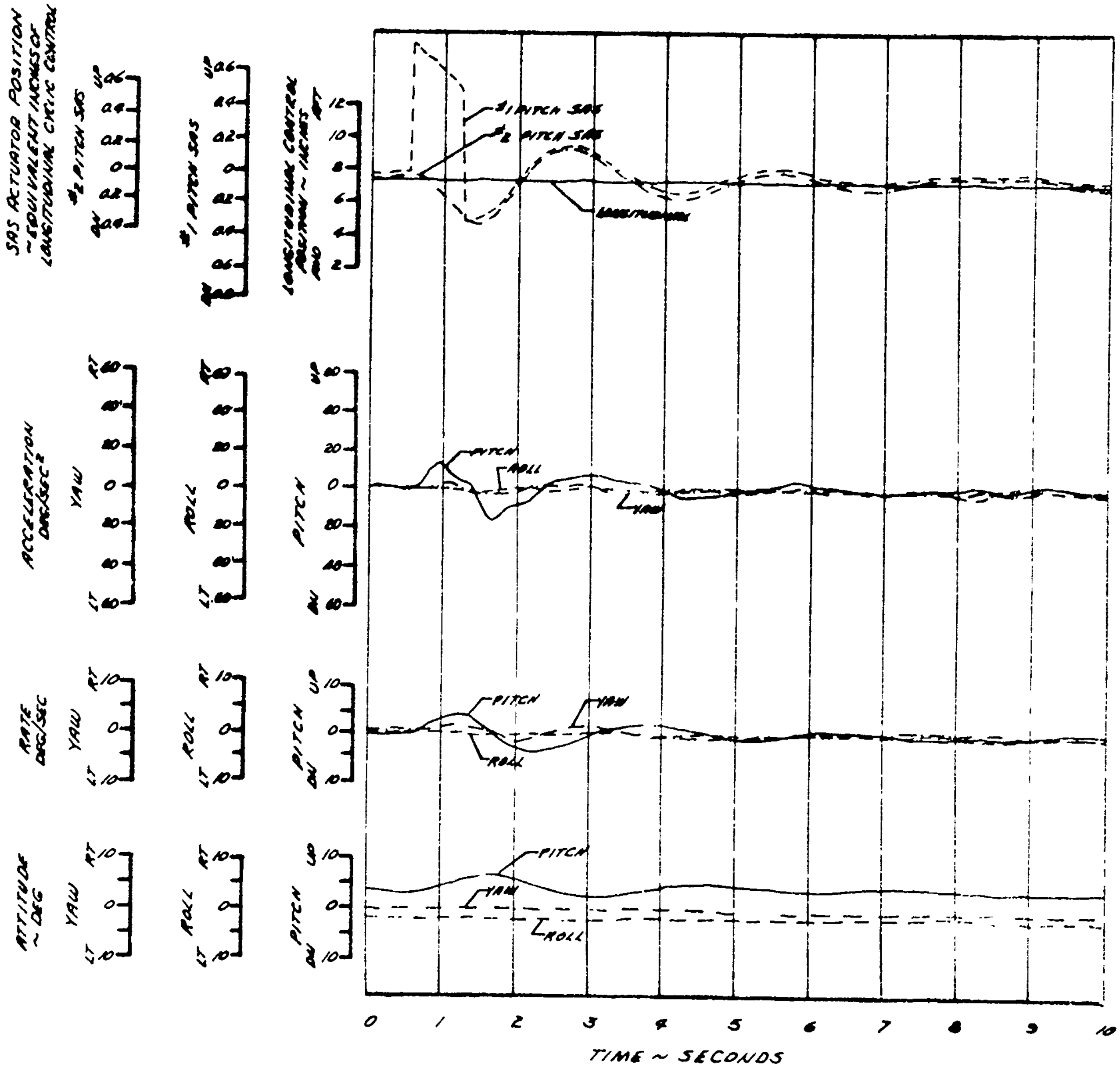
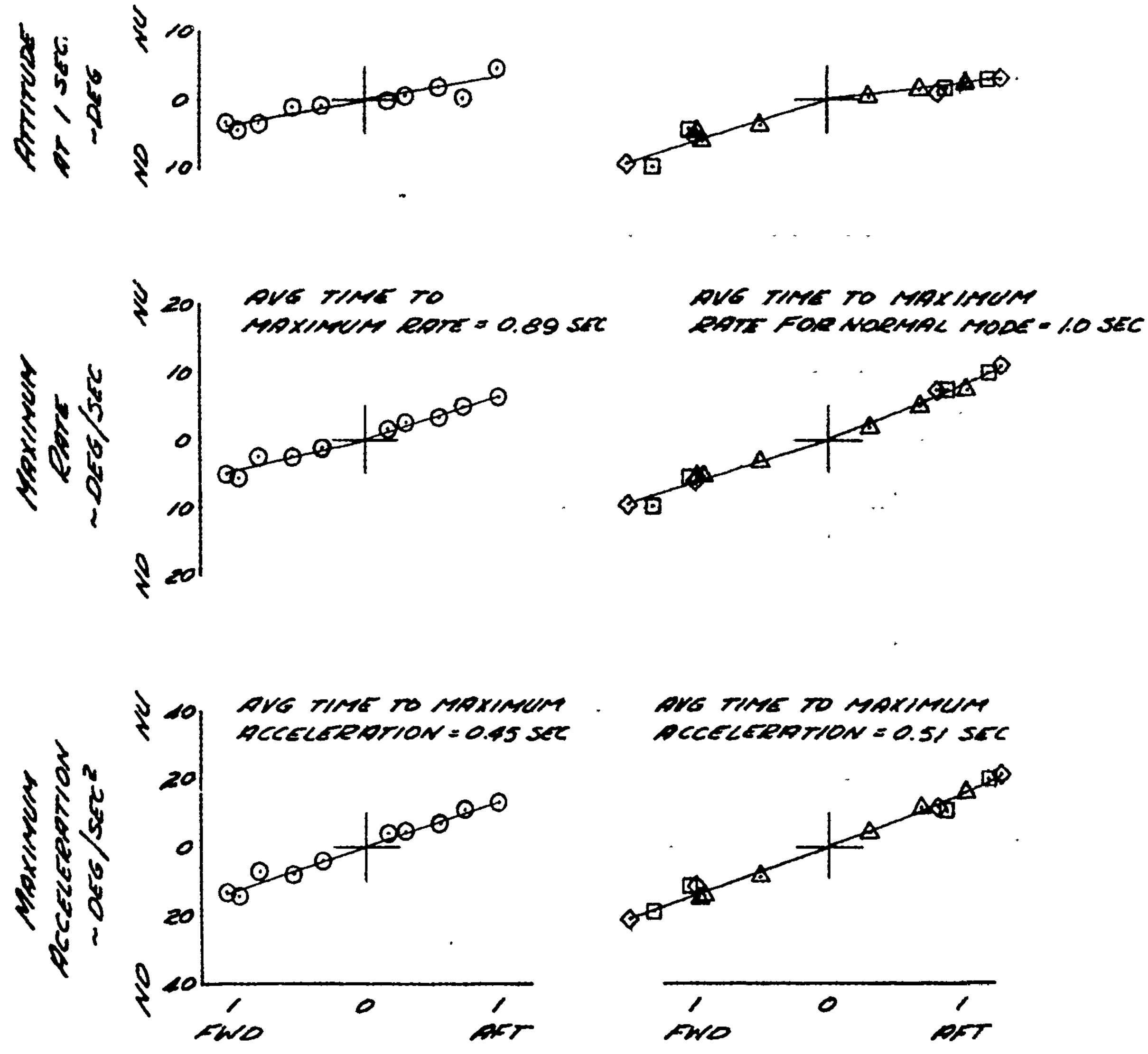


FIGURE 31
LONGITUDINAL CONTROLLABILITY
CH-47C USA S/N 68-15859
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	45220	4900	14.0	334.0 (AFT)	245	.006571	84	NORMAL
□	44890	4780	24.5	336.0 (AFT)	245	.006499	103	AUTO
△	46460	4670	16.5	335.2 (AFT)	245	.006705	106	NORMAL
◇	44890	4780	24.5	336.0 (AFT)	245	.006499	103	OFF

NOTE: RATE DURING PSA MODE IN AUTO AND OFF MEASURED AT 1 SECOND



CONTROL DISPLACEMENT FROM TRIM ~INCHES

FIGURE 32
LONGITUDINAL CONTROLLABILITY
CH-47C USA S/N 68-15859
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	45450	4800	16.5	335.9 (AFT)	245	.006586	82	OFF
□	45750	4890	21.0	335.1 (AFT)	245	.006645	103	NORMAL

NOTE: 10,000 LB SLING LOAD

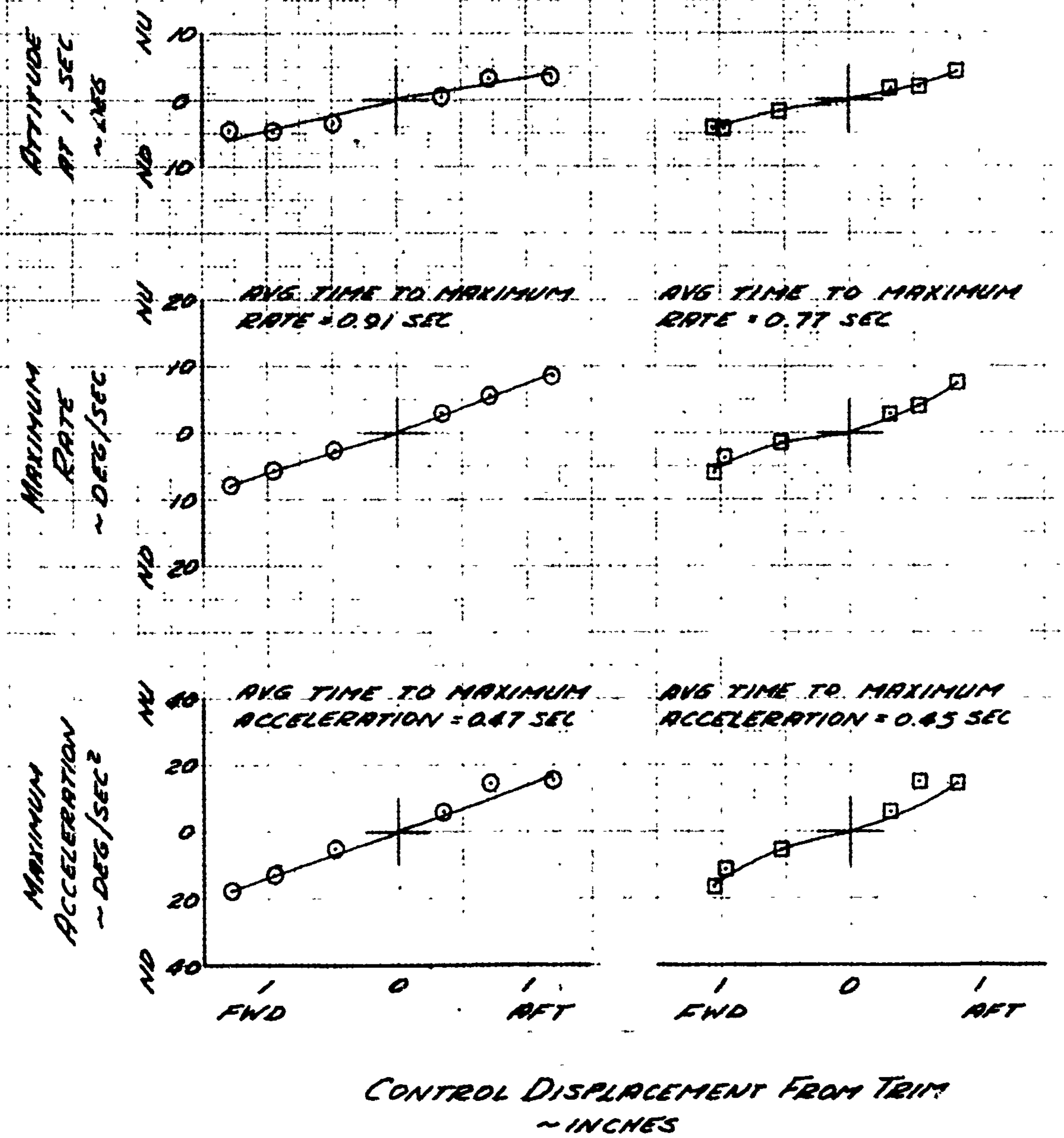


FIGURE 33
LONGITUDINAL CONTROLLABILITY
CH-47C USA S/N 68-15859
HOVER

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	44330	3960	24.0	335.6 (AFT)	245	.006261	HOVER	OFF
□	46880	2030	10.0	334.2 (AFT)	245	.006251	HOVER	OFF
△	44510	2570	13.5	336.0 (AFT)	245	.006031	HOVER	NORMAL
◇	45740	3710	22.5	334.6 (AFT)	245	.006413	HOVER	AUTO

NOTE: ⊙ DENOTE 10,000 LB SLING LOAD

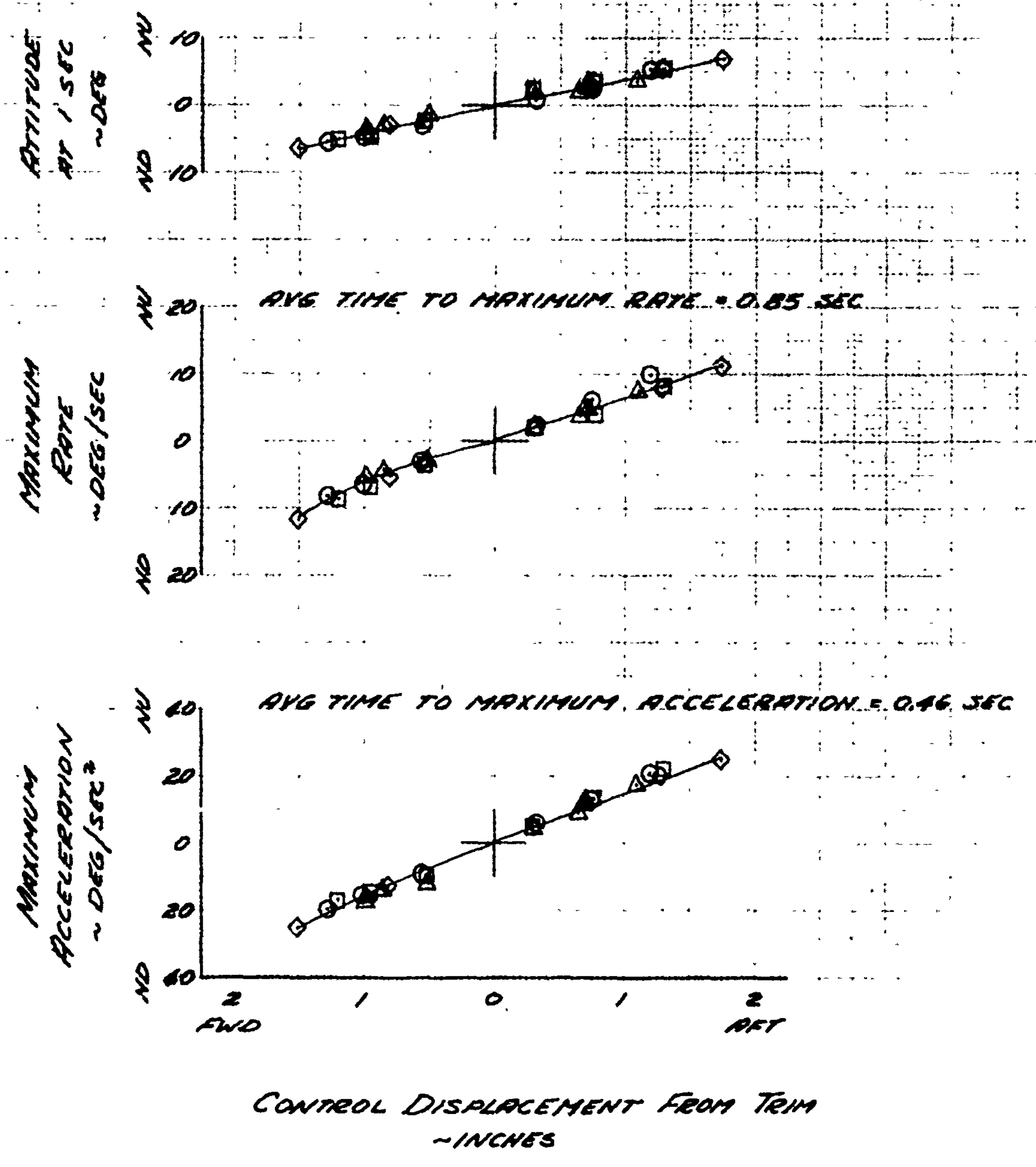


FIGURE 34
LONGITUDINAL CONTROLLABILITY
CH-47C USA S/N 68-15839
CLIMB AND AUTOROTATION

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN)	AVG ROTOR SPEED (RPM)	AVG G	AVG TRIM A/S (KCAS)	PSA MODE
○	45440	4000	11.0	334.8 (AFT)	245	.006427	78	OFF
□	45770	4970	19.0	335.5 (AFT)	245	.006666	80	NORMAL
△	45030	5650	8.0	335.0 (AFT)	245	.006695	80	OFF
◇	45770	4970	19.0	335.5 (AFT)	245	.006666	80	NORMAL

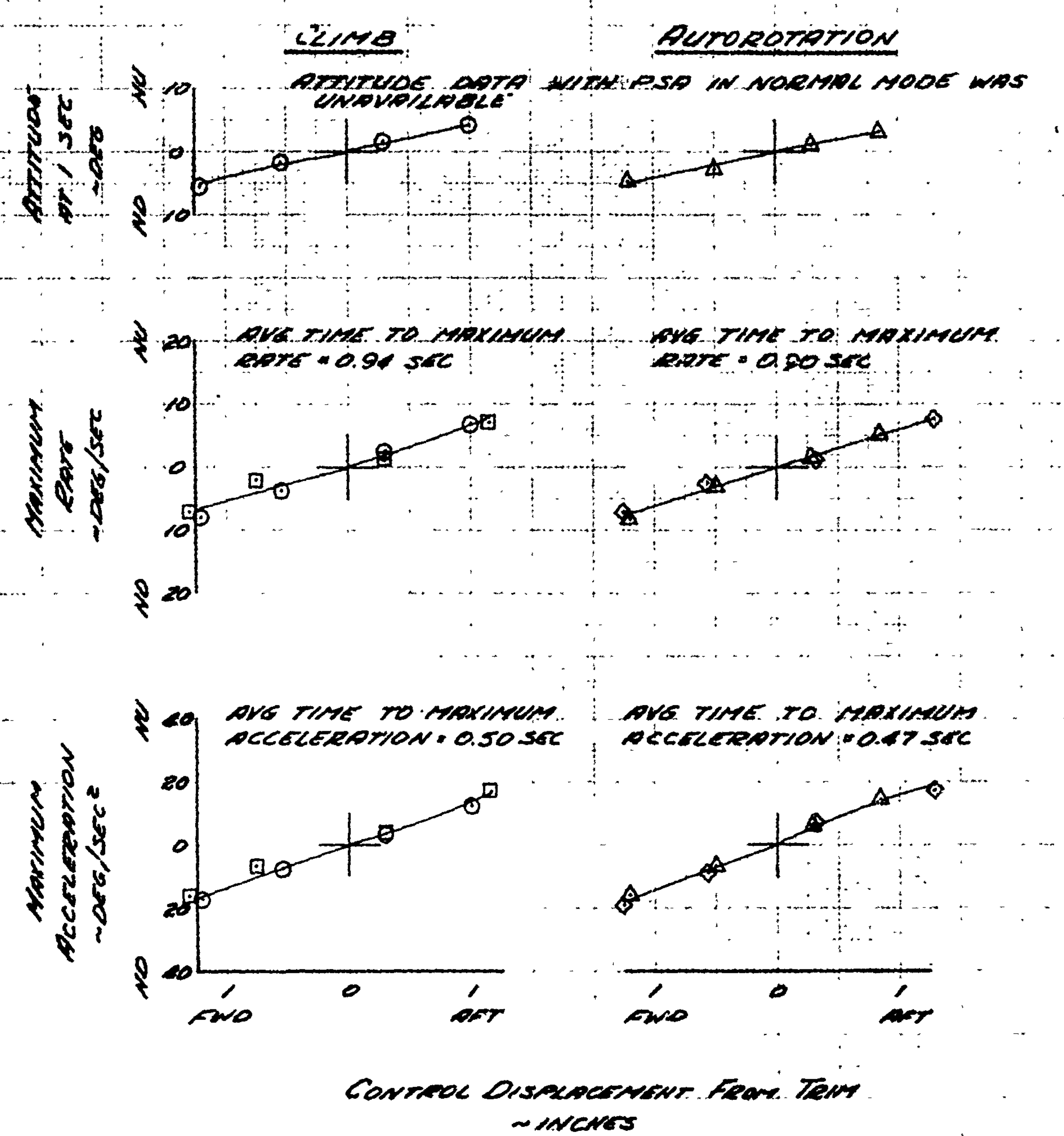
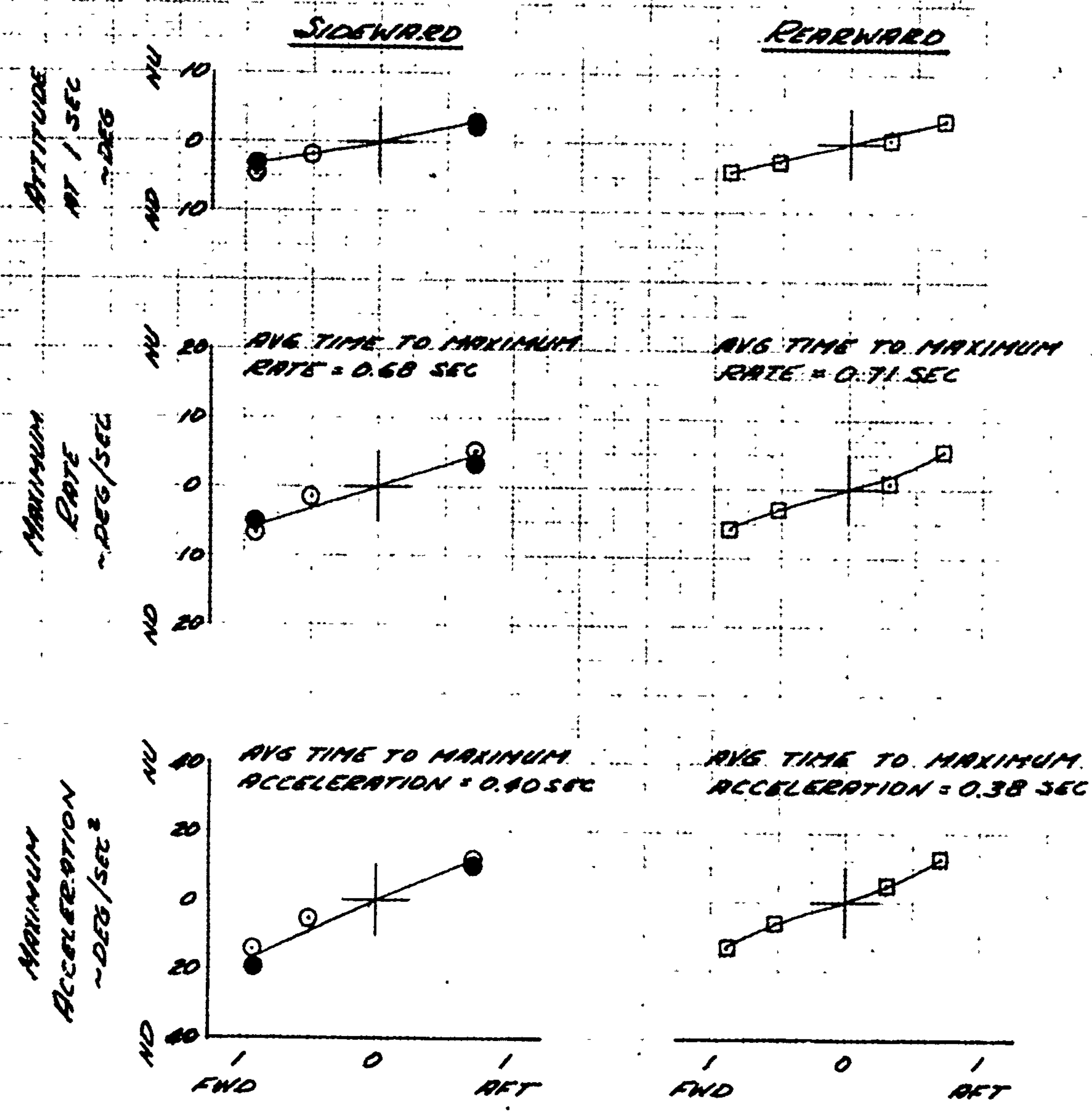


FIGURE 35
LONGITUDINAL CONTROLLABILITY
CH-47C USA S/N 68-15859
SIDEWARD AND REARWARD

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSM MODE
○	44670	2210	10.0	336.0 (AFT)	245	.005989	35	OFF
□	46040	2180	10.0	335.4 (AFT)	245	.006167	30	OFF

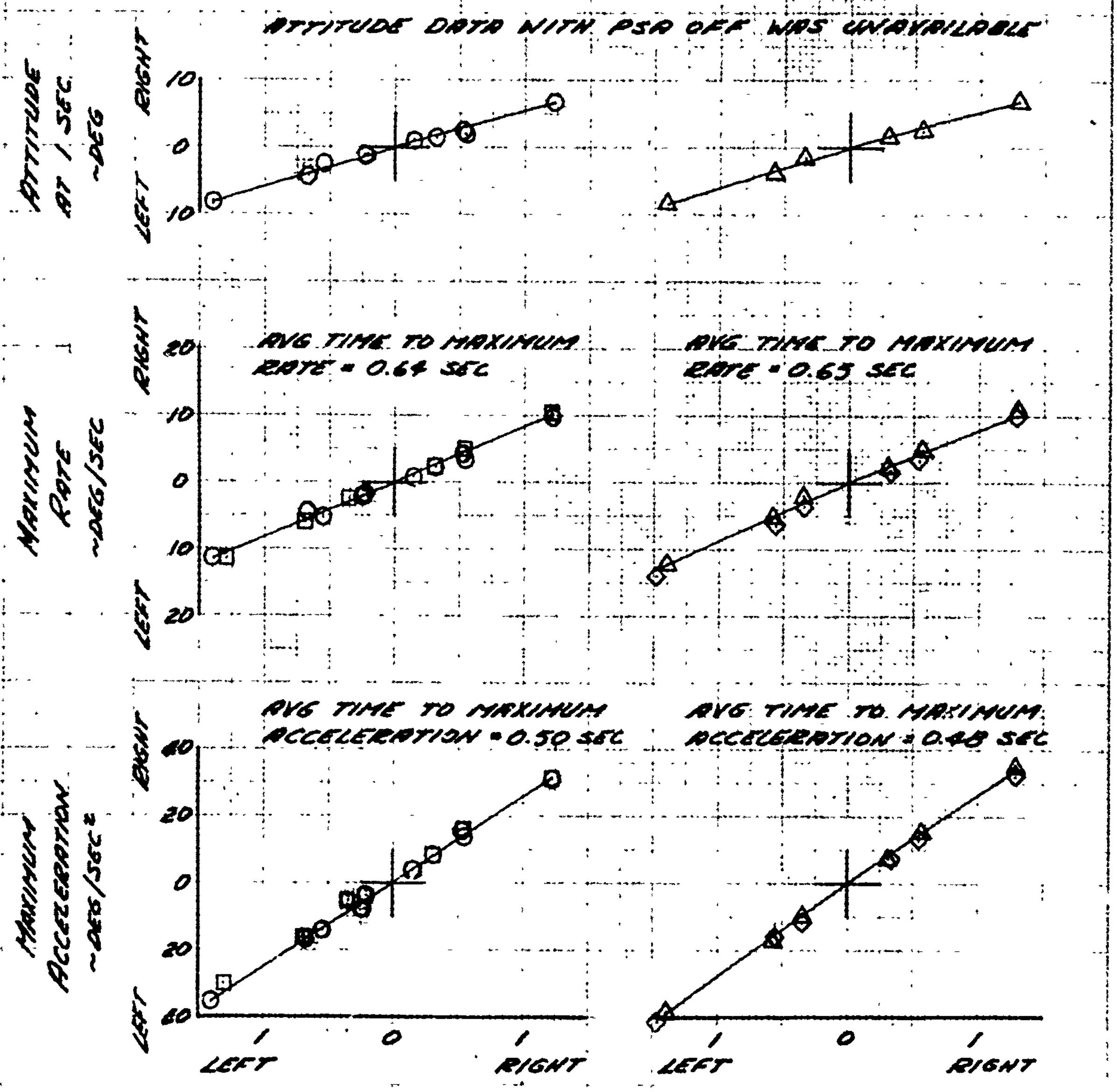
NOTE: 1. OPEN SYM DENOTES LEFT SIDEWARD FLT
2. SHADED SYM DENOTES RIGHT SIDEWARD FLT



CONTROL DISPLACEMENT FROM TRIM
~INCHES

FIGURE 36
LATERAL CONTROLLABILITY
CH-47C USA S/N 68-15859
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	46210	4800	14.0	335.7 (AFT)	245	.006695	84	NORMAL
□	45700	5090	17.5	335.5 (AFT)	245	.006679	84	OFF
△	45800	4700	16.0	335.5 (AFT)	245	.006617	105	NORMAL
◇	46640	4850	18.0	335.1 (AFT)	245	.006768	102	OFF



CONTROL DISPLACEMENT FROM TRIM
~INCHES

FIGURE 37
LATERAL CONTROLLABILITY
CH-47C USA S/N 68-15859
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
□	45100	4660	16.5	336.1 (AFT)	245	.006506	84	OFF
△	45290	4980	21.0	335.3 (AFT)	245	.006596	103	NORMAL

NOTE: 10,000 LB SLING LOAD

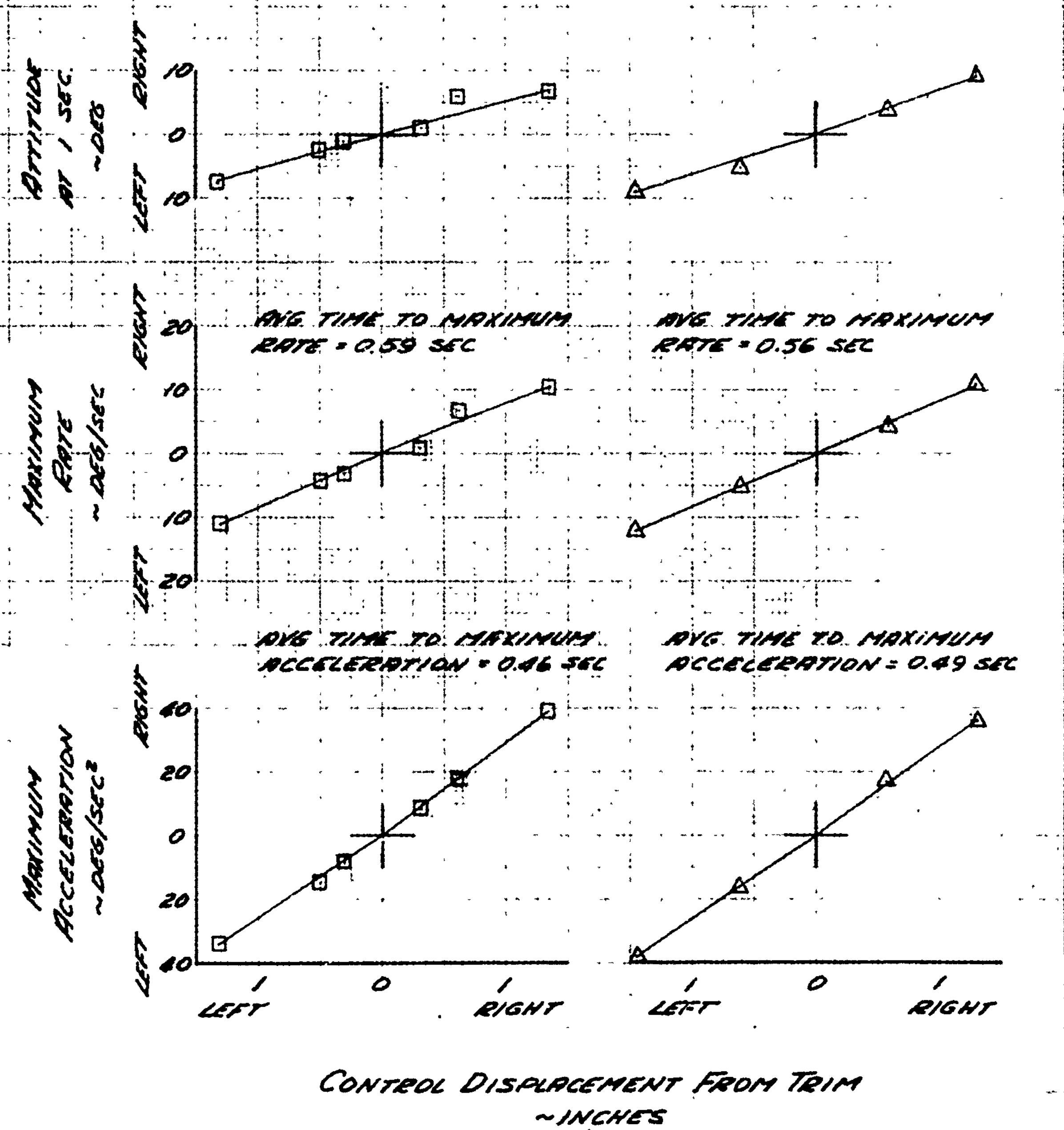
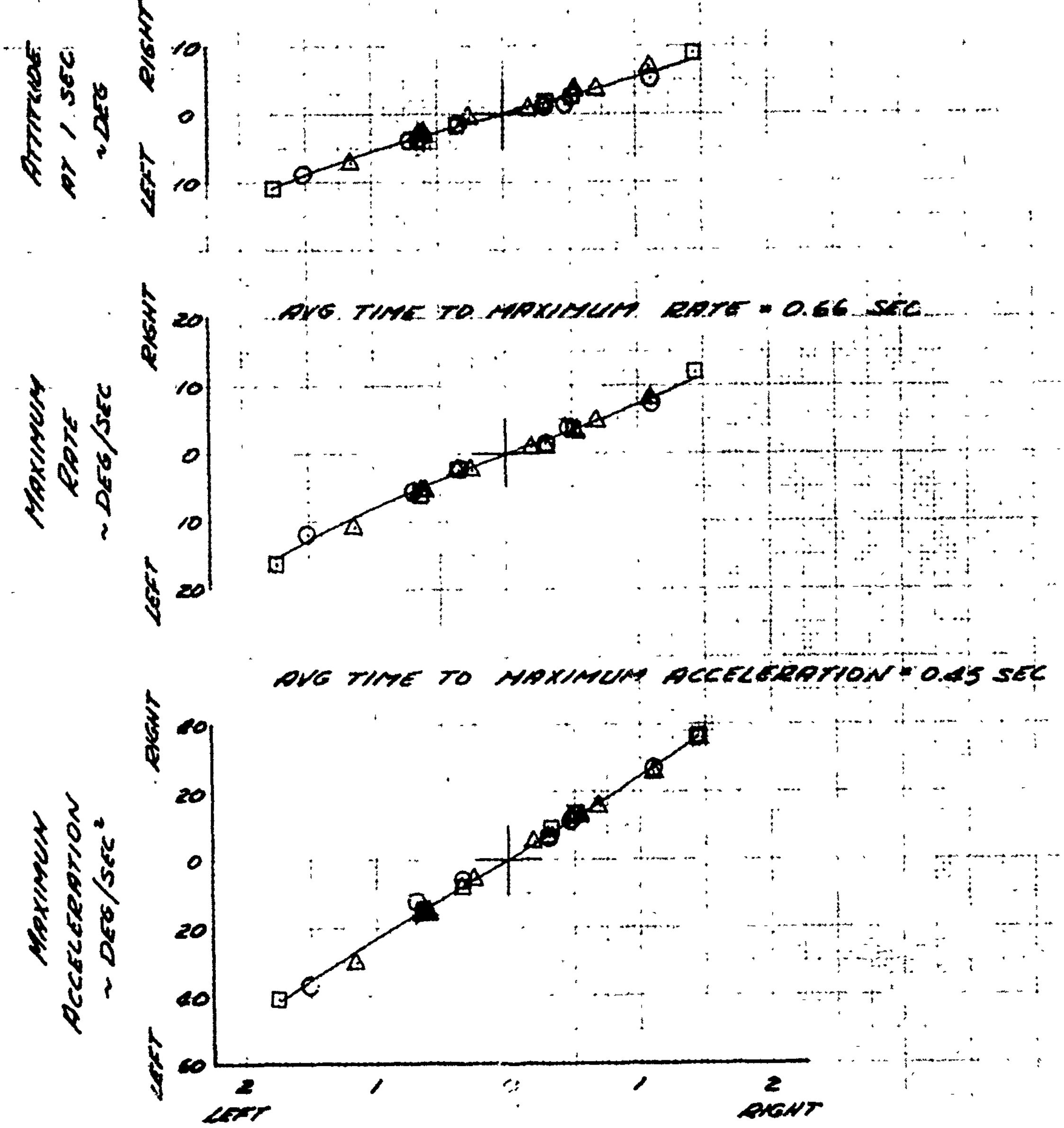


FIGURE 38
LATERAL CONTROLLABILITY
CH-47C USA S/N 68-15859
HOVER

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG C.G. LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	44010	4020	24.5	335.8 (AFT)	245	.006226	HOVER	OFF
□	46460	2050	10.0	334.4 (AFT)	245	.006199	HOVER	OFF
△	43950	2360	12.0	334.5 (AFT)	245	.005918	HOVER	NORMAL

NOTE: ○ DENOTES 10,000 LB SLING LOAD



CONTROL DISPLACEMENT FROM TRIM
~INCHES

FIGURE 39
LATERAL CONTROLLABILITY
CH-47C USA S/N 68-15859
CLIMB AND AUTOROTATION

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	45030	5650	8.0	335.0 (AFT)	245	.006695	80	OFF
□	45200	4970	19.0	335.7 (AFT)	245	.006582	80	NORMAL
△	44500	5730	7.5	335.2 (AFT)	245	.006535	80	OFF
◇	45210	4970	19.0	335.7 (AFT)	245	.006583	80	NORMAL

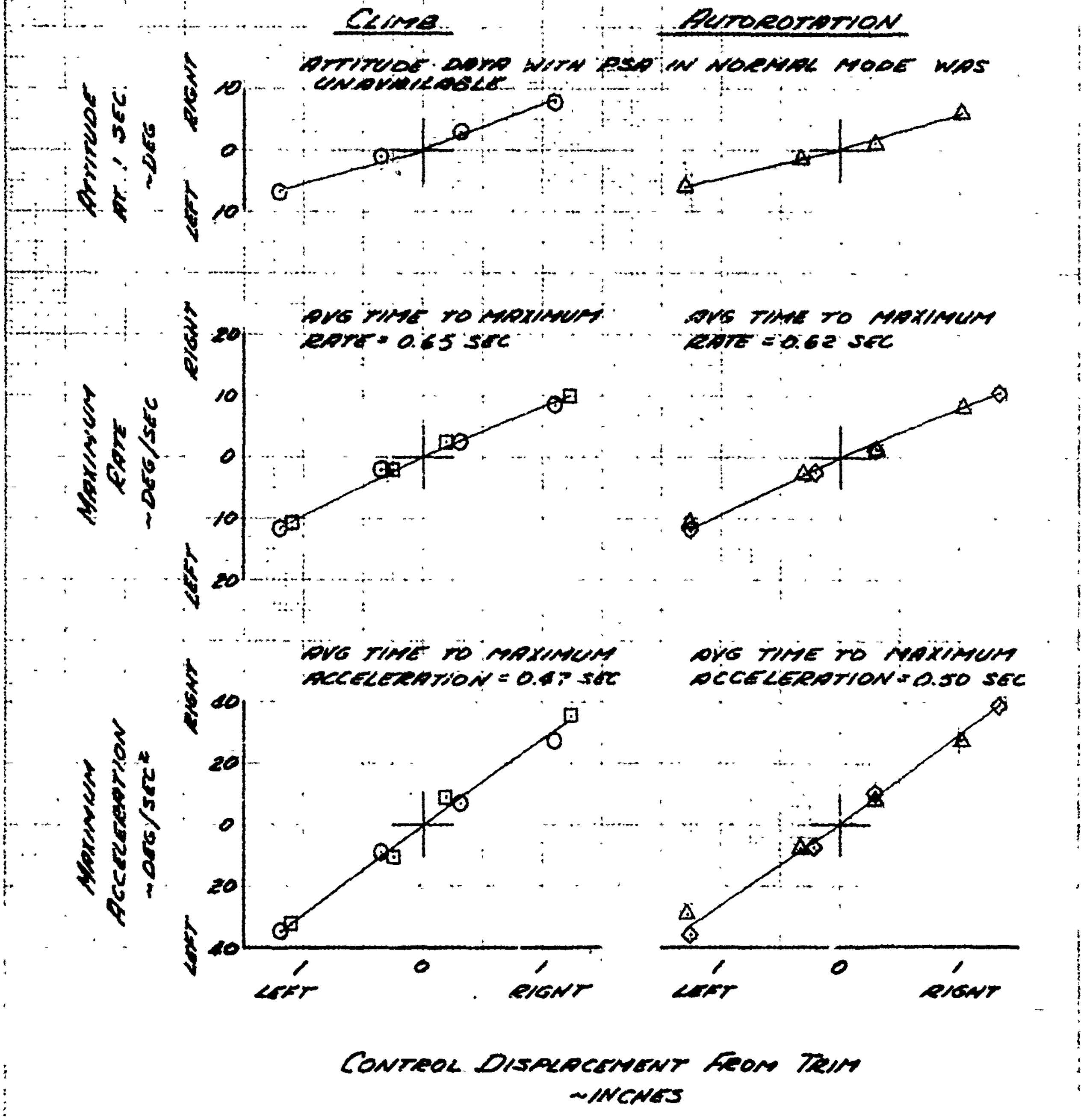


FIGURE 40
LATERAL CONTROLLABILITY
CH-47C USA S/N 68-15859
SIDEWARD AND REARWARD

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	45070	2270	10.0	335.8 (AFT)	245	.006053	35	OFF
□	45730	2100	9.5	335.5 (AFT)	245	.006111	30	OFF

NOTE: 1. OPEN SYM DENOTES LEFT SIDEWARD FLT
2. SHADED SYM DENOTES RIGHT SIDEWARD FLT

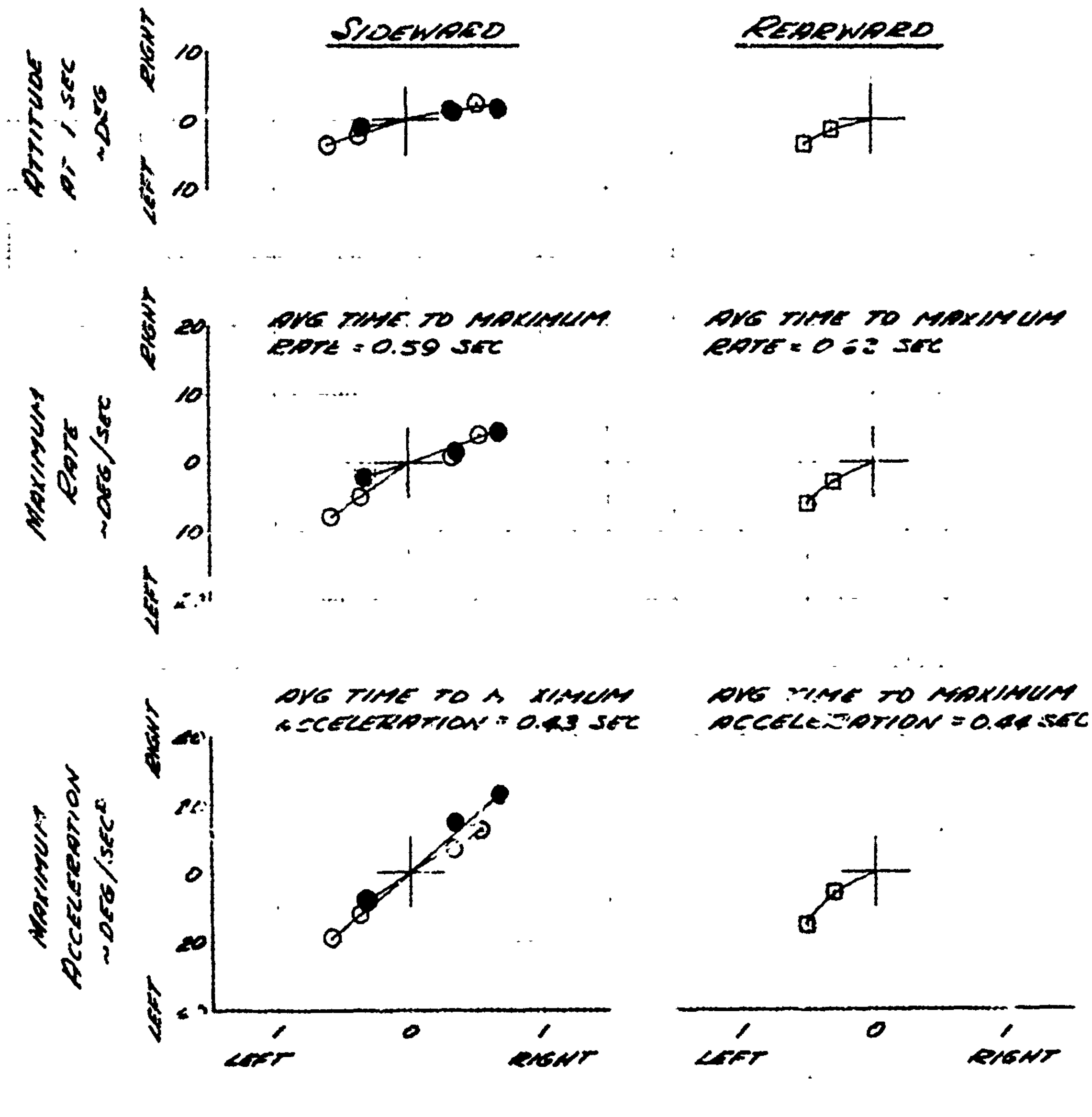


FIGURE 41
DIRECTIONAL CONTROLLABILITY
CH-47C USA S/N 68-15859
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	46210	4800	14.0	334.7 (AFT)	245	.006695	84	NORMAL
□	45320	4900	17.5	335.6 (AFT)	245	.006586	85	OFF
△	45680	4590	16.5	335.5 (AFT)	245	.006576	105	NORMAL
◇	46310	4740	18.5	335.3 (AFT)	245	.006697	102	OFF

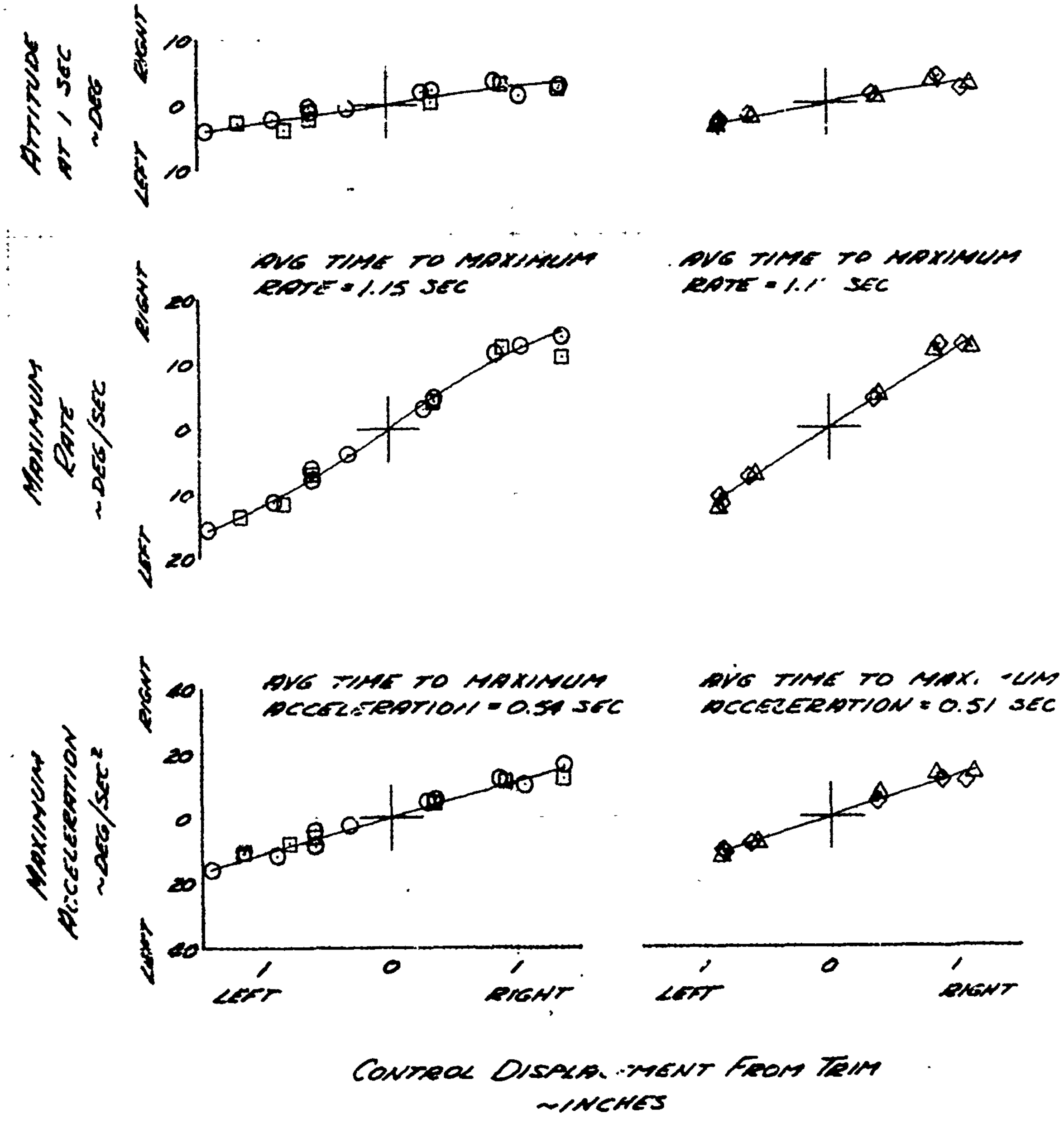


FIGURE 42
DIRECTIONAL CONTROLLABILITY
CH-47C USA S/N 68-15859
LEVEL FLIGHT

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
□	44830	4750	14.5	336.2 (AFT)	245	.006484	84	OFF
△	44990	5050	20.5	335.4 (AFT)	245	.006563	103	NORMAL

NOTE: 10,000 LB SLING LOAD

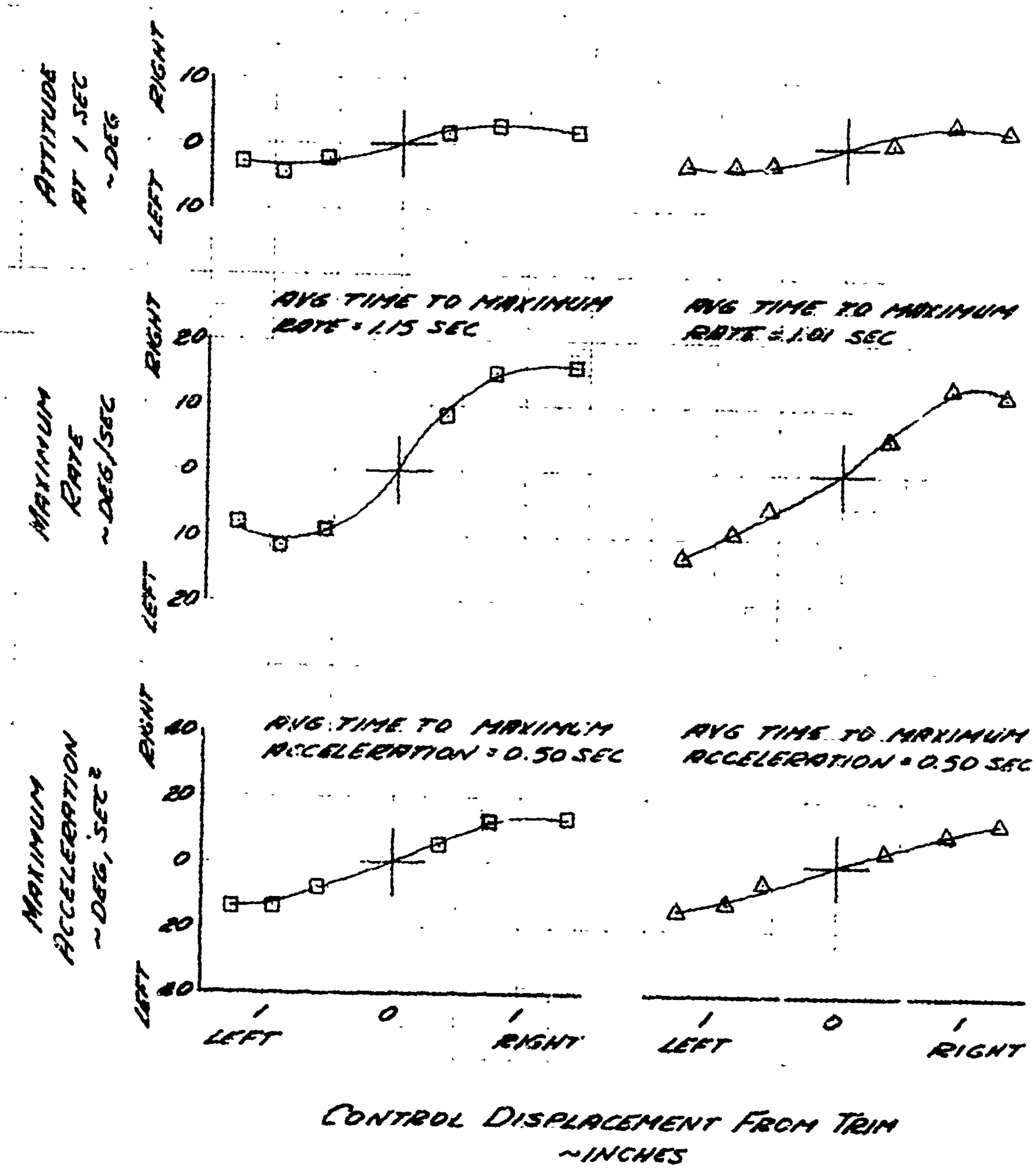


Figure 43
Directional Controllability
CH-47C USA S/N 68-158[illegible]9
Hover

Sym	Avg Gross Weight (LB)	Avg Density Altitude (FT)	Avg OAT (°C)	Avg CG Location (IN.)	Avg Rotor Speed (RPM)	Avg C_T	Avg Trim A/S (KCAS)	PSA Mode
○	43720	4040	24.5	335.9 (AFT)	245	.006191	Hover	Off
□	46050	2050	9.5	334.6 (AFT)	245	.006144	Hover	Off
△	44730	2540	13.0	335.9 (AFT)	245	.006056	Hover	Normal

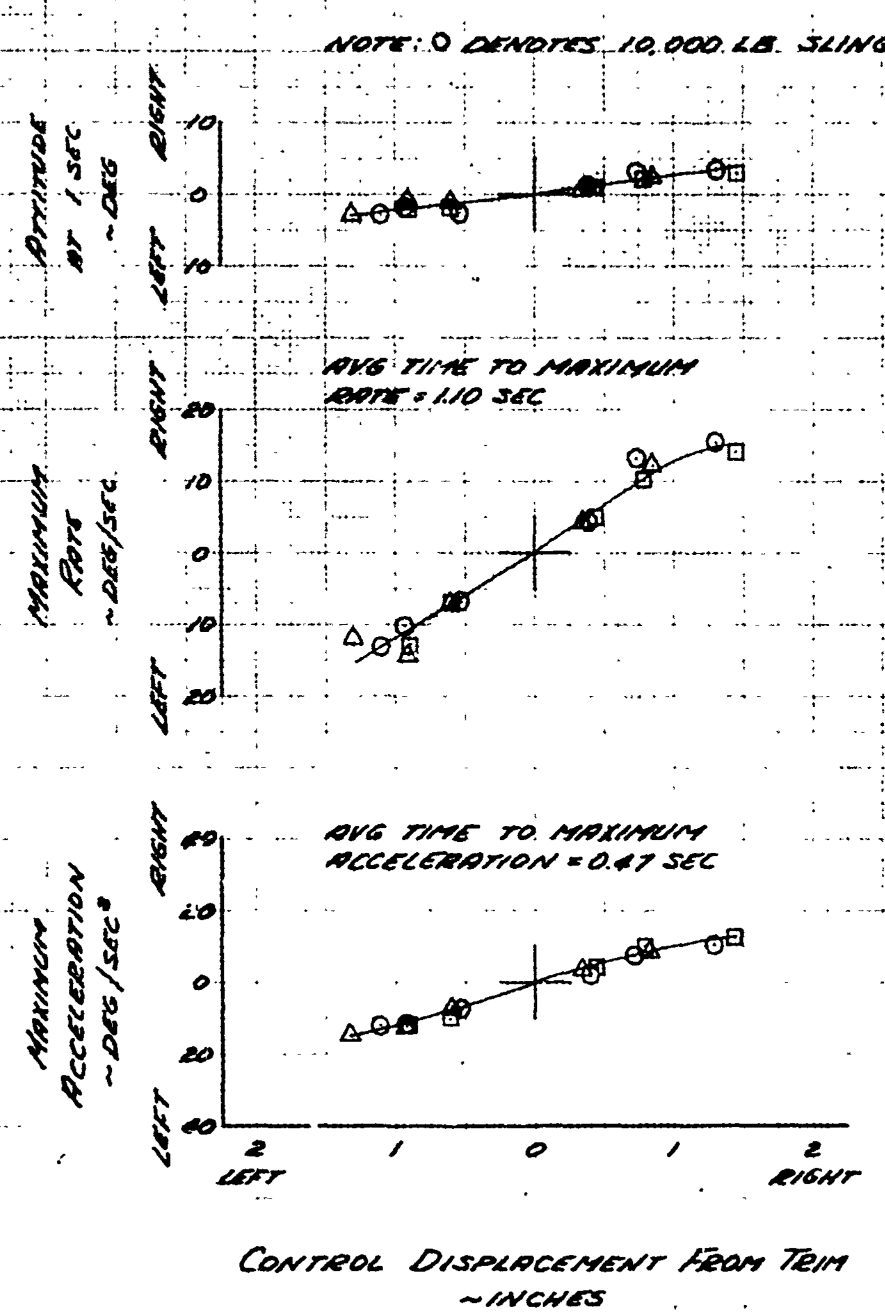
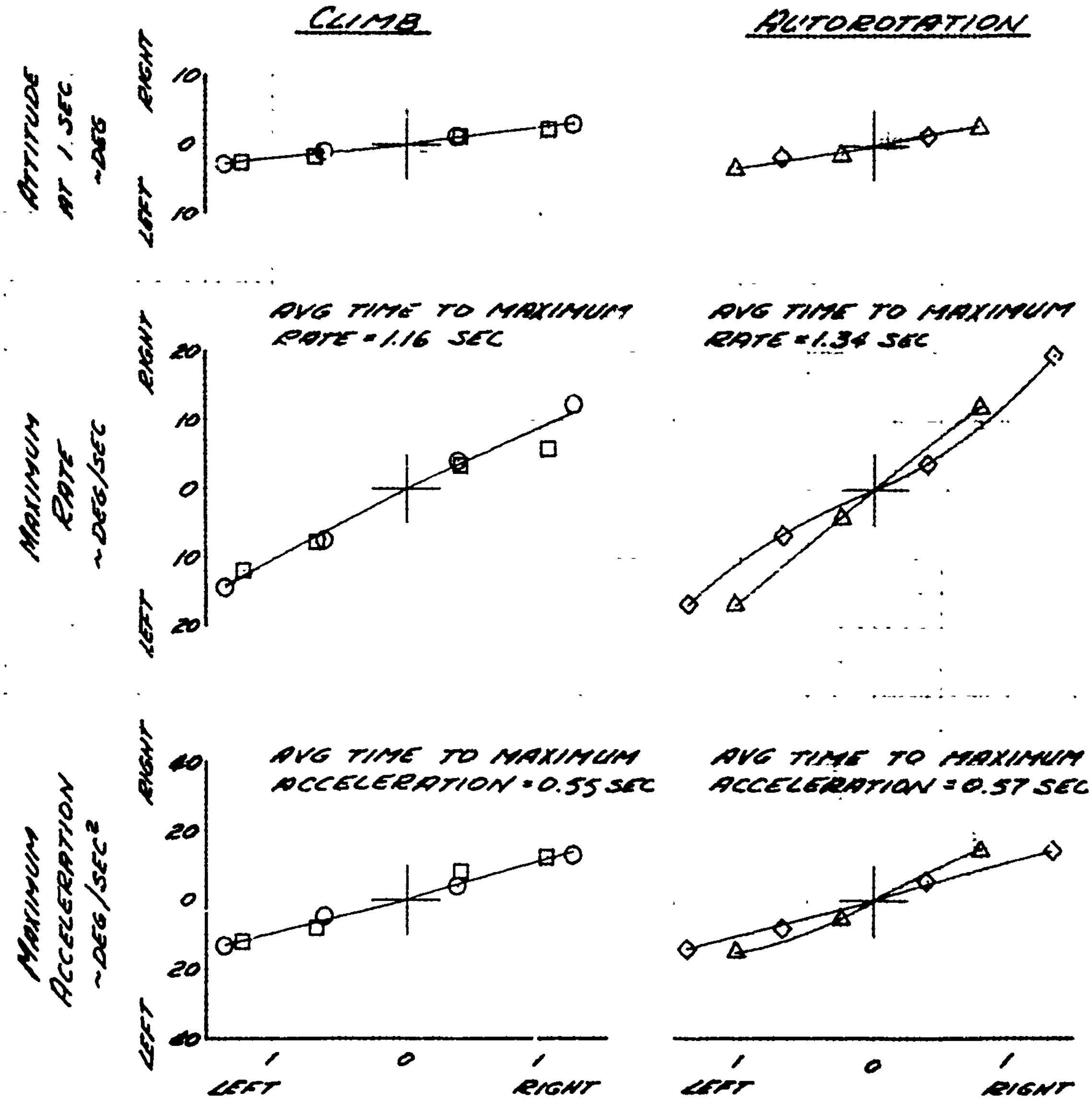


FIGURE 44
DIRECTIONAL CONTROLLABILITY
CH-47C USA S/N 68-15859
CLIMB AND AUTOROTATION

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	44660	5400	8.0	335.1 (AFT)	245	.006589	79	OFF
□	45080	4970	19.0	335.8 (AFT)	245	.006565	80	NORMAL
△	44310	4270	10.0	335.2 (AFT)	245	.006317	81	OFF
◇	45080	4970	19.0	335.8 (AFT)	245	.006565	80	NORMAL

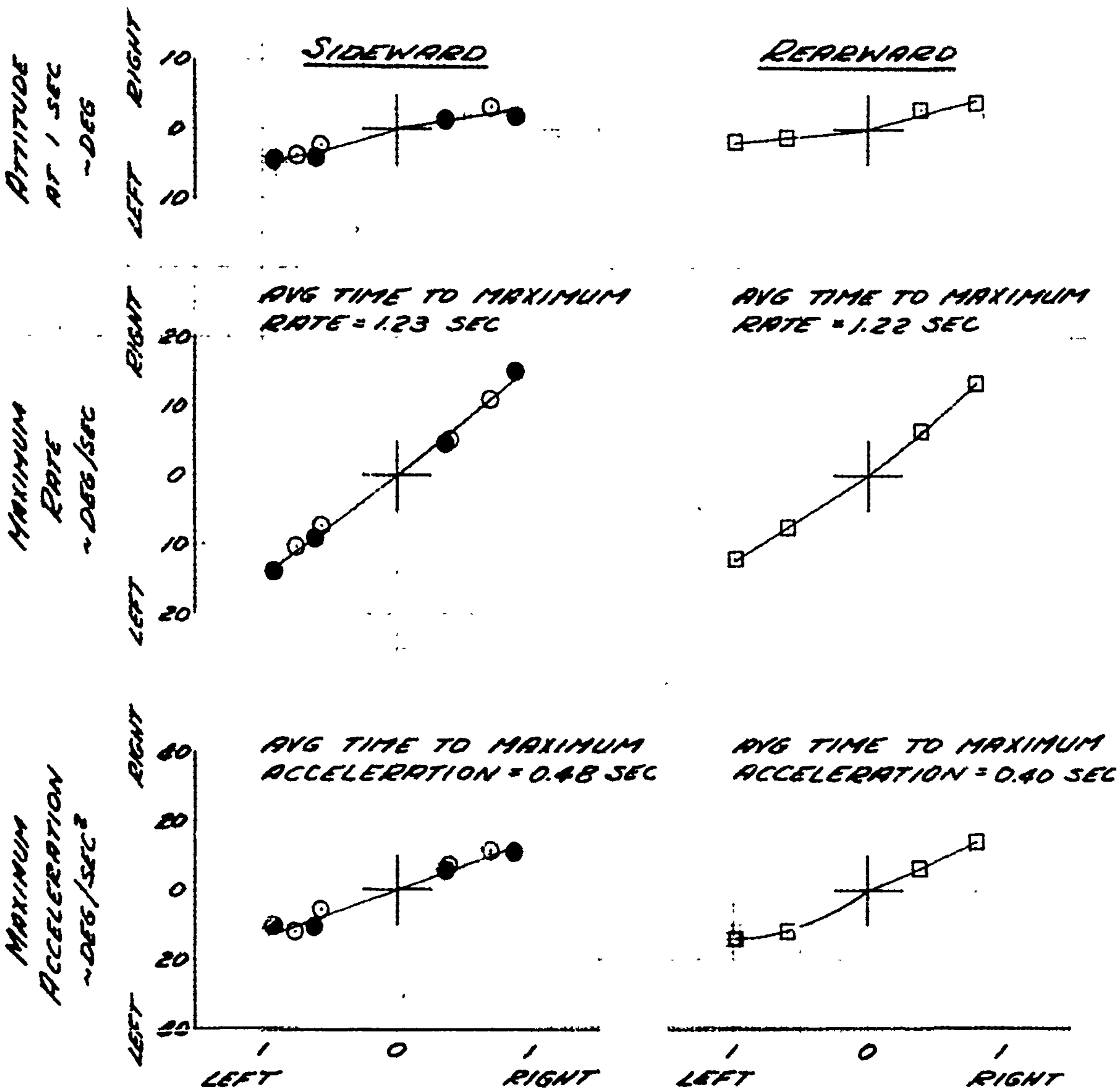


CONTROL DISPLACEMENT FROM TRIM
~INCHES

FIGURE 45
DIRECTIONAL CONTROLLABILITY
CH-47C USA S/N 68-15859
SIDEWARD AND REARWARD

SYM	AVG GROSS WEIGHT (LB)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG CG LOCATION (IN.)	AVG ROTOR SPEED (RPM)	AVG C_T	AVG TRIM A/S (KCAS)	PSA MODE
○	44430	2200	10.0	336.0 (AFT)	245	.005955	35	OFF
□	45500	2130	9.5	335.6 (AFT)	245	.006085	30	OFF

NOTE: 1. OPEN SYM DENOTES LEFT SIDEWARD FLT
2. SHADED SYM DENOTES RIGHT SIDEWARD FLT



CONTROL DISPLACEMENT FROM TRIM ~INCHES

FIGURE 46
CONTROL SYSTEM CHARACTERISTICS
CH-47C USA S/N 68-15859

NOTE: 1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC PRESSURE

2. CONTROL CENTERING ON

3. TOTAL LONGITUDINAL CONTROL TRAVEL = 14.13 IN.

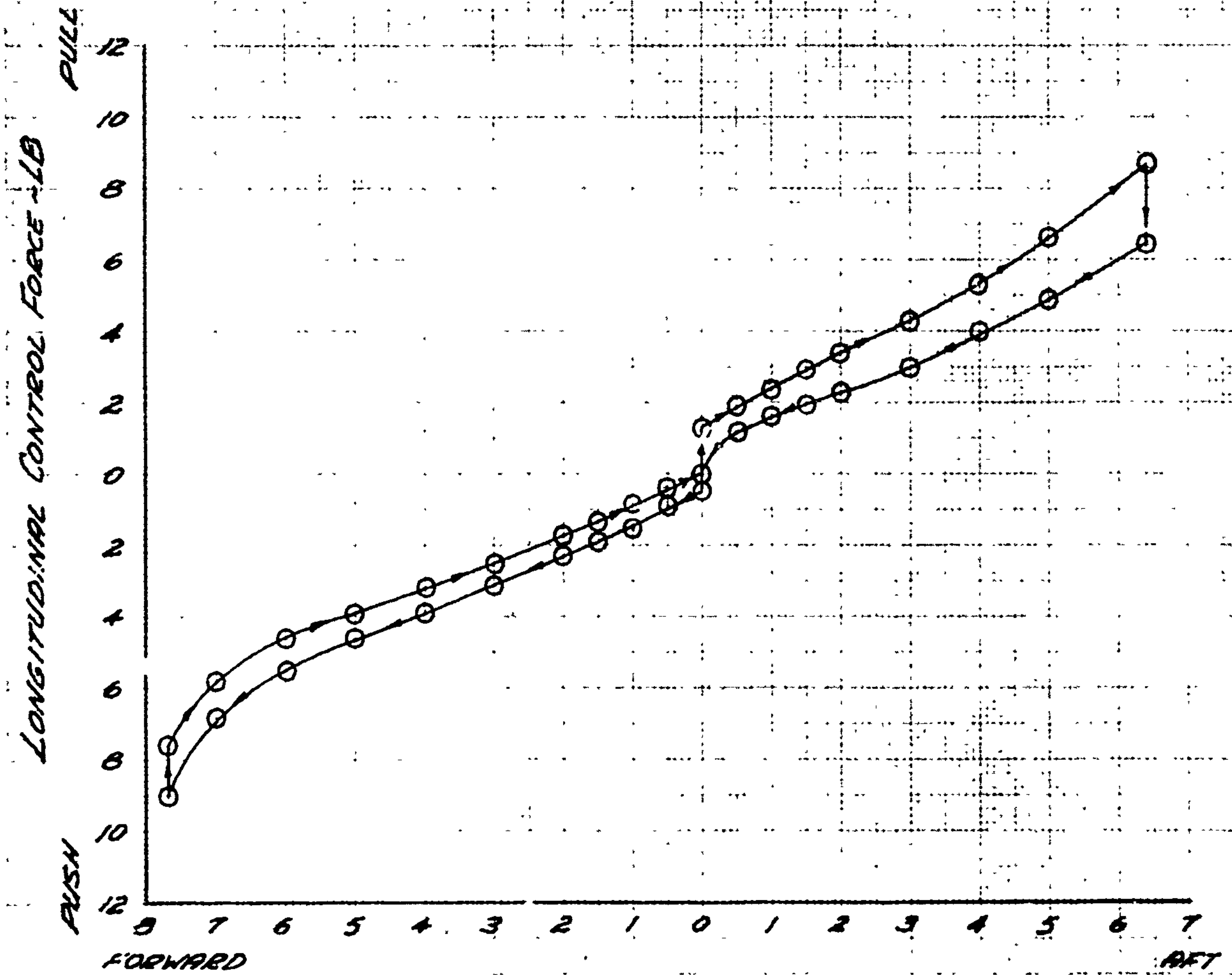


FIGURE 47
CONTROL SYSTEM CHARACTERISTICS
CH-47C USA S/N 68-15859

NOTE: 1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC PRESSURE
2. CONTROL CENTERING ON
3. TOTAL LATERAL CONTROL TRAVEL = 8.25 IN.

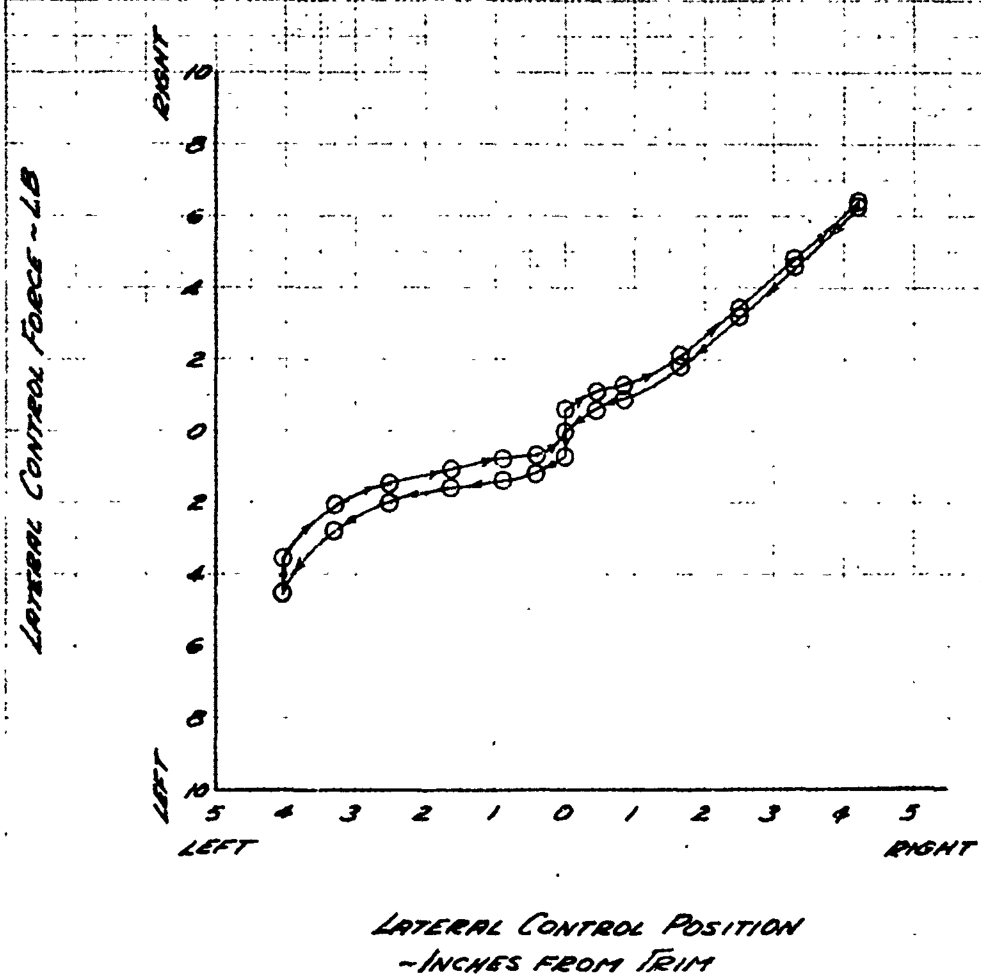
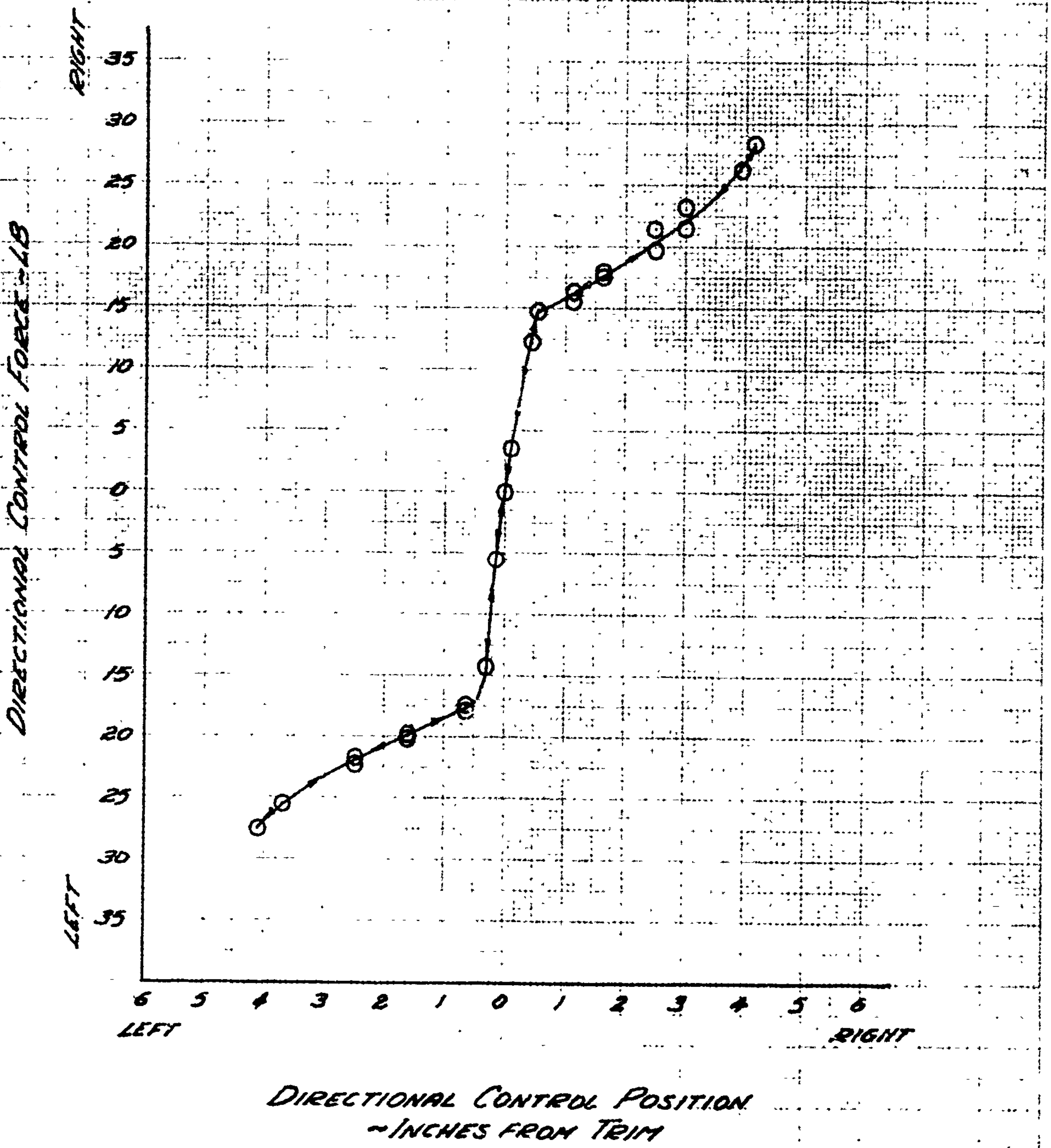


FIGURE 48
CONTROL SYSTEM CHARACTERISTICS
CH-47C USA S/N 68-15859

NOTE: 1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC PRESSURE

2. CONTROL CENTERING ON

3. TOTAL DIRECTIONAL CONTROL TRAVEL = 8.25 IN.



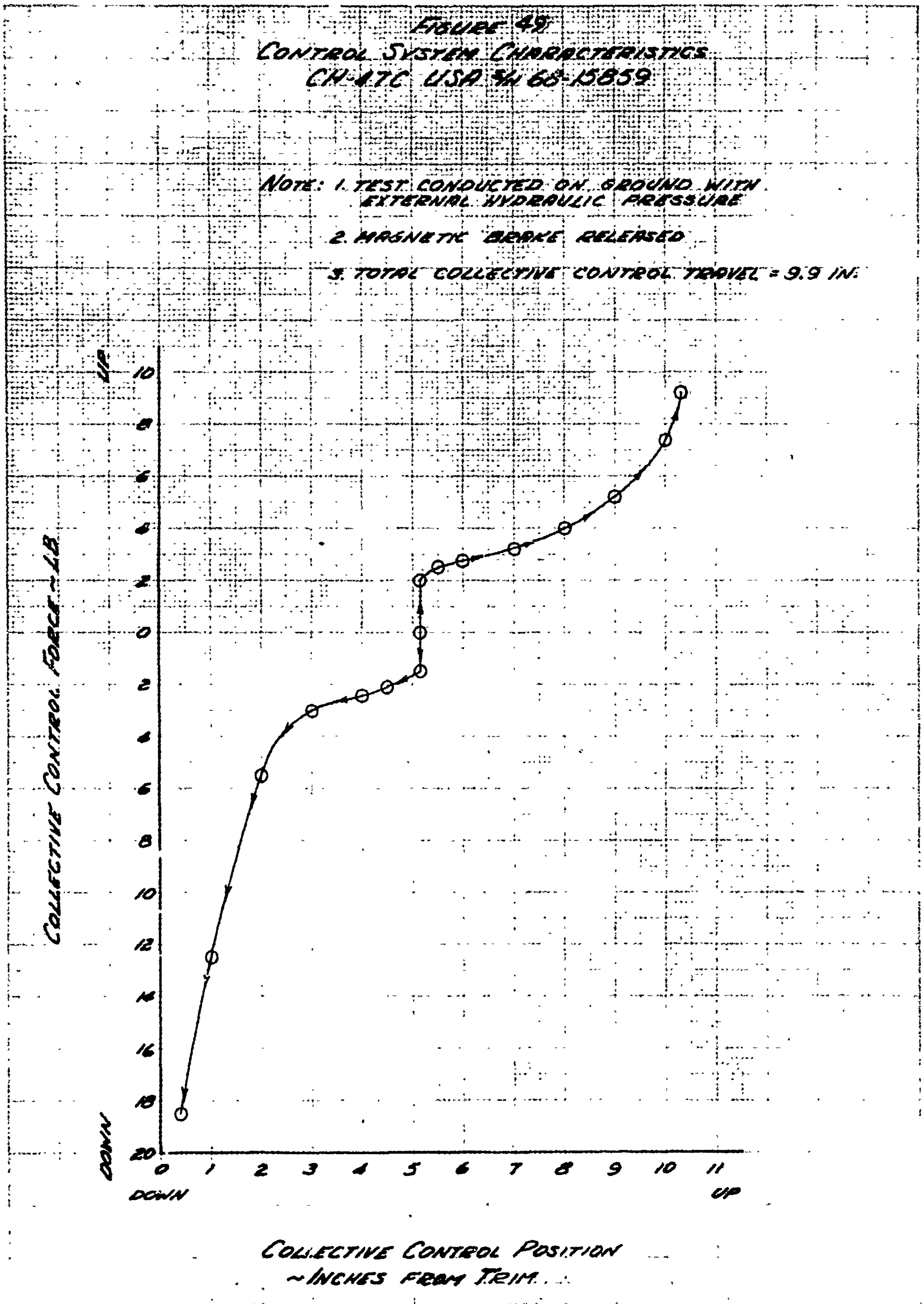


FIGURE 49
CONTROL SYSTEM CHARACTERISTICS
CH-47C USA S/N 68-15859
NOTE: 1. TEST CONDUCTED ON GROUND WITH EXTERNAL HYDRAULIC PRESSURE
2. MAGNETIC BRAKE RELEASED
3. TOTAL COLLECTIVE CONTROL TRAVEL = 9.9 IN.
COLLECTIVE CONTROL FORCE ~ LB
UP
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
DOWN
0
1
2
3
4
5
6
7
8
9
10
11
DOWN
UP
COLLECTIVE CONTROL POSITION
~INCHES FROM TRIM

FIGURE 30

AIRCRAFT RESPONSE FOLLOWING A SIMULATED SINGLE ENGINE FAILURE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN.)	INITIAL ROTOR SPEED (RPM)	INITIAL C_T	TRIM A/S (KCAS)	INITIAL ENGINE TORQUE #1 (%)	INITIAL ENGINE TORQUE #2 (%)
32,800	5000	27.0	338.5(AFT)	235	0.005196	137	78.0	78.0

NOTE: PSA = NORMAL MODE

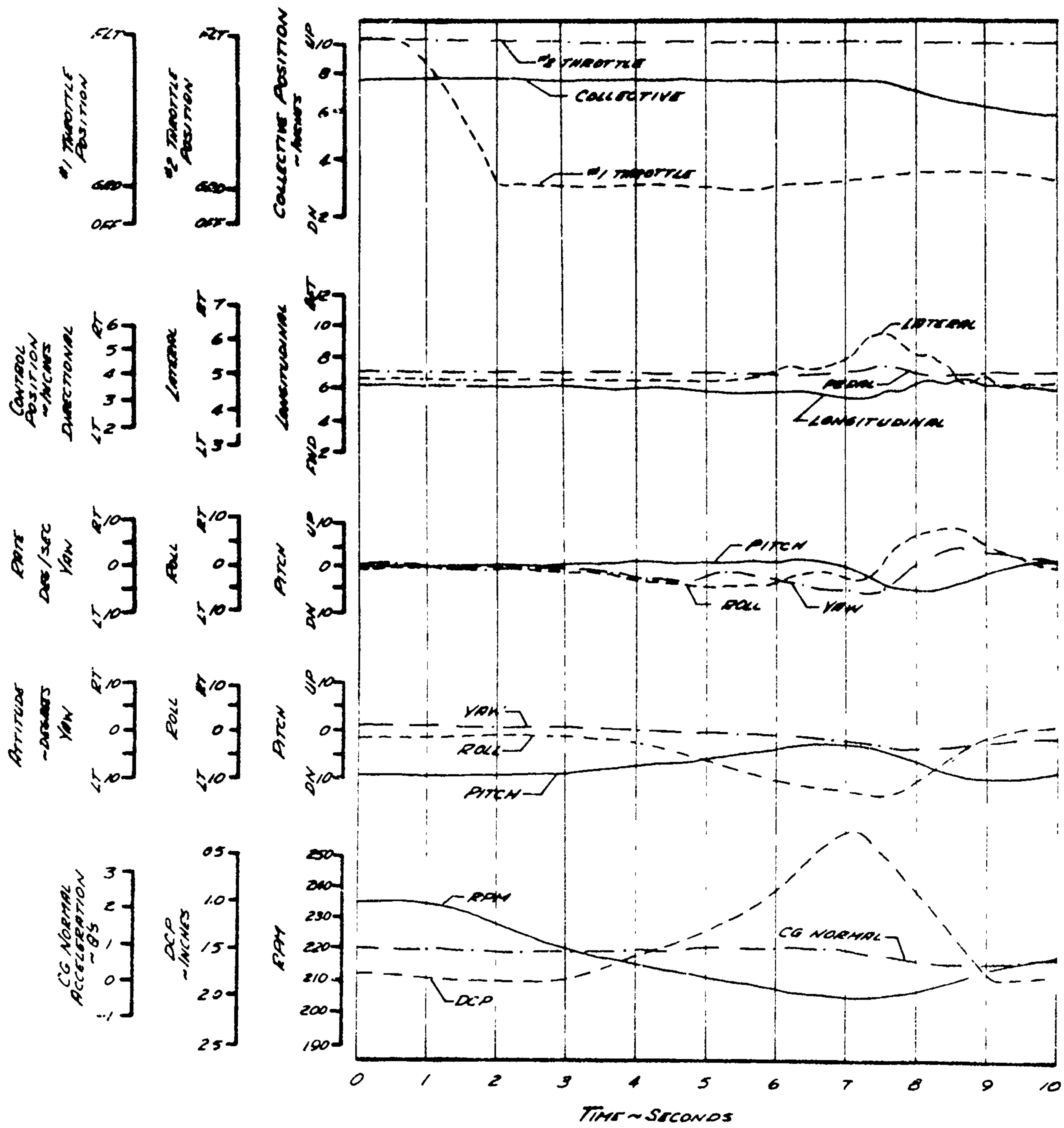


FIGURE 31

AIRCRAFT RESPONSE FOLLOWING A SIMULATED SINGLE ENGINE FAILURE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN.)	INITIAL ROTOR SPEED (RPM)	INITIAL A/G C_T	TRIM A/S (KCAS)	INITIAL ENGINE TORQUE (%) #1	#2
32,570	3000	26.5	338.7 (AFT)	235	0.005160	137	78.0	78.0

NOTE: PSA ~ OFF

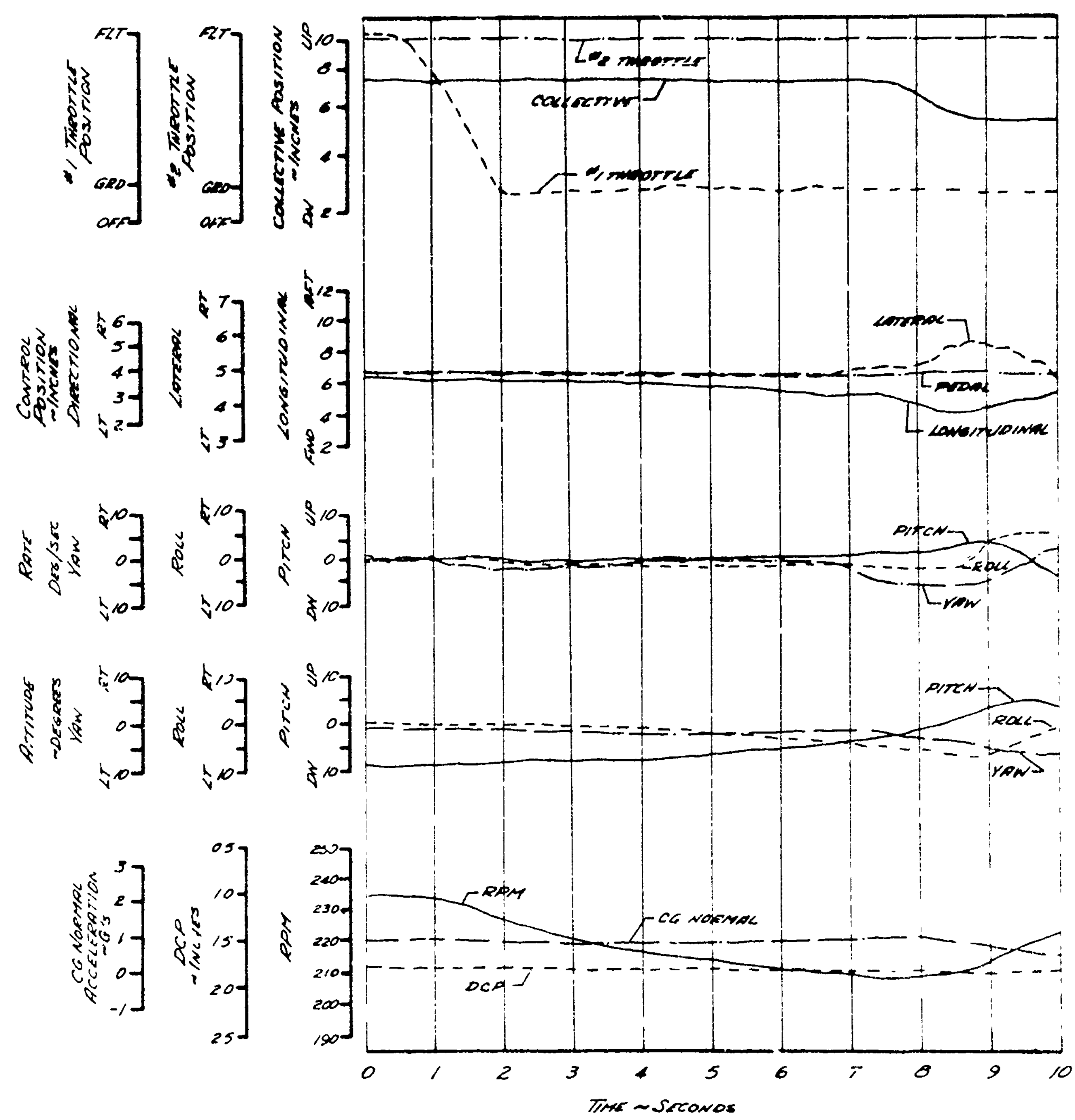


FIGURE 52

AIRCRAFT RESPONSE FOLLOWING A SIMULATED SINGLE ENGINE FAILURE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN.)	INITIAL ROTOR SPEED (RPM)	INITIAL C_T	TRIM A/S (KCAS)	INITIAL ENGINE TORQUE #1 (%)	#2
44,460	5000	14.5	386.3 (AFT)	245	0.006480	101	67.0	68.0

NOTE: PSA ~ NORMAL MODE

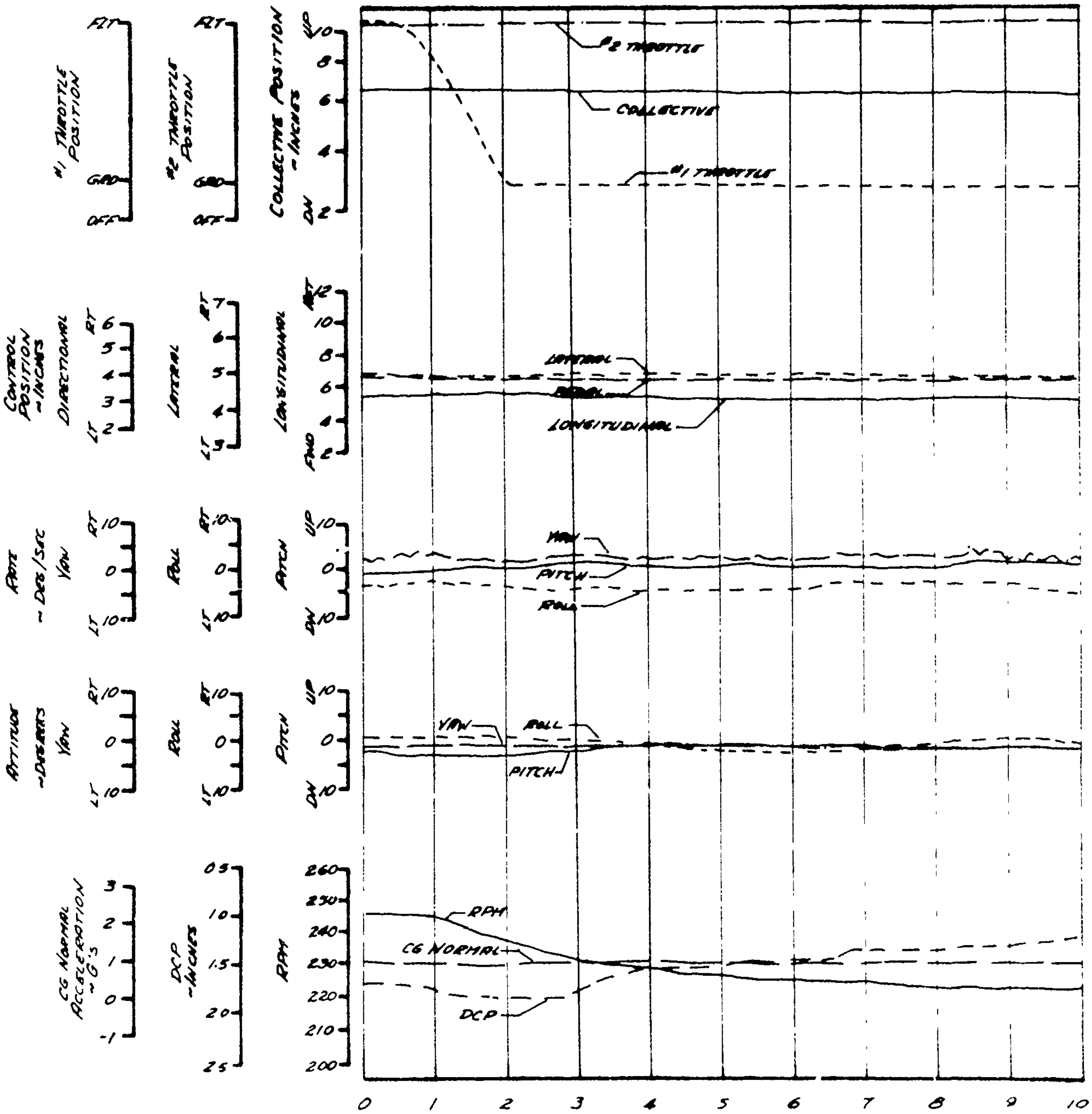


FIGURE 53

AIRCRAFT RESPONSE FOLLOWING A SIMULATED DUAL ENGINE FAILURE

CH-47C USA S/N 68-15859

Gross Weight (LB)	Density Altitude (FT)	OAT (°C)	CG Location (IN)	Initial Rotor Speed (RPM)	Initial C_T	Trim A/S (KCAS)	Initial Engine Torque #1 (%)	Initial Engine Torque #2 (%)
32,360	5000	27.0	338.8 (AFT)	235	0.00512	129	71.0	71.0

NOTE: PSA ~ NORMAL MODE

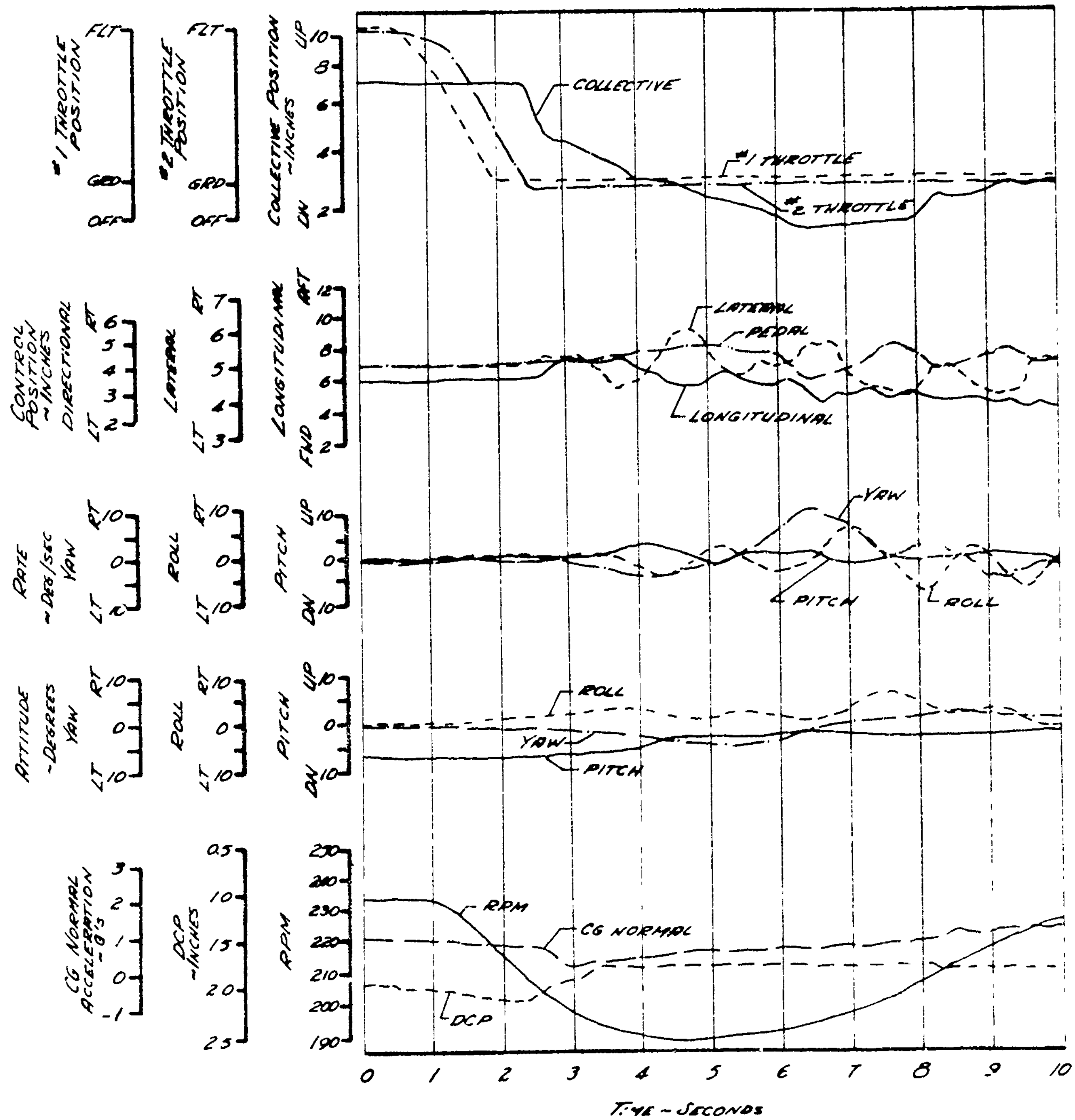


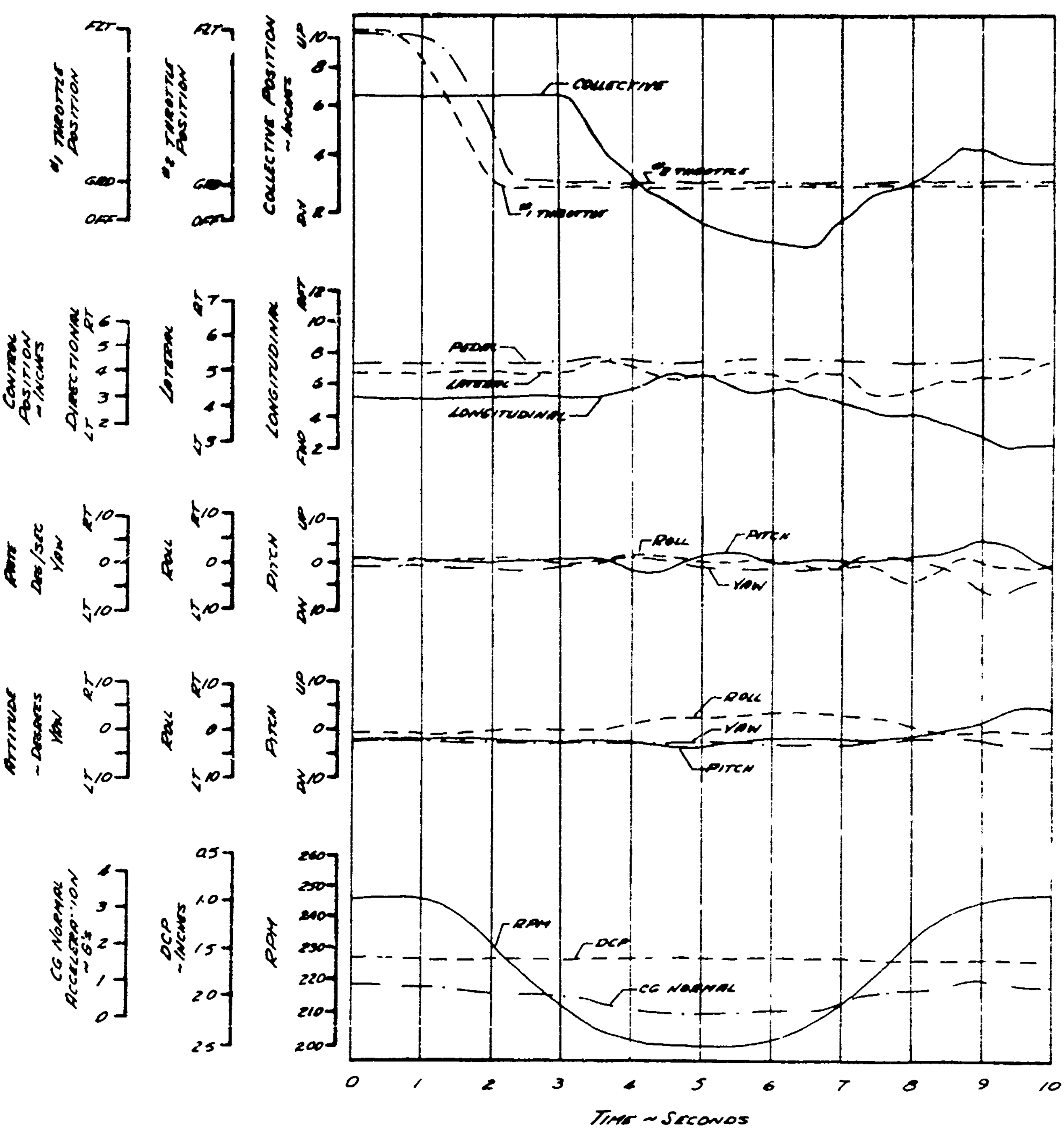
FIGURE 54

AIRCRAFT RESPONSE FOLLOWING A SIMULATED DUAL ENGINE FAILURE

CH-47C USA S/N 68-15859

GROSS WEIGHT (LB)	DENSITY ALTITUDE (FT)	OAT (°C)	CG LOCATION (IN)	INITIAL ROTOR SPEED (RPM)	INITIAL C_T	TRIM A/S (KCAS)	INITIAL ENGINE TORQUE #1 (%)	#2
44,050	5000	8.5	385.8 (AFT)	245	0.006564	104	62.0	60.0

NOTE: PSA ~ OFF



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13 ABSTRACT

The second phase of the CH-47C airworthiness and flight characteristics (A&FC) test program consisted of the stability and control test of the production helicopter. Tests were conducted in California at Edwards Air Force Base during the period 8 March to 15 July 1971. The CH-47C was evaluated to determine compliance with the military specification, MIL-H-8501A, with deviations as defined in the detail specification. The helicopter was also evaluated with respect to its mission as a transport helicopter. The CH-47C stability and control characteristics are acceptable for the transport helicopter mission. Correction of the deficiency of excessive torque split with T55-L-11A engines is mandatory prior to operational use. Twelve shortcomings were found during this test. Static longitudinal stability characteristics (with the pitch stability augmentation system (PSA) OFF) failed to meet requirements of the detail specification. The dynamic stability characteristics with the PSA system OFF failed to meet the requirements of the military specification, and the hover directional control power failed to meet the requirements of the military specification. An investigation is recommended to determine the cause of torque splits with the T55-L-11A engines. Additional recommendations are to prohibit intentional flight in instrument conditions with one stability augmentation system (SAS) inoperative and to place a "WARNING" in the operator's manual stating that during instrument flight with only one SAS operating, failure of that SAS could result in a loss of aircraft control. The CH-47C should also be equipped with a structural load indicator.

14 KEY WORDS	LINK A		LINK B		LINK C	
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CH-47C stability and control characteristics						
deficiency of excessive torque split						
Twelve shortcomings						
Warning						